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e-mail: aftmt@uni-ruse.bg

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CONTENT Page

Material Properties Analysis after Heat Treatment

Petr Dostal, Miroslav Pristavka, Plamen Kangalov, Nela Polakova, David Dobrocky

Abstract: *This article addresses the influence of heat treatment and corrosion degradation on the mechanical properties of material. The introduction contains information related to the issue of the steel heat treatment theory. The aim of this article is to verify the influence of recrystallization annealing, hardening and refining on the mechanical properties of high-quality carbon steel 12 050. After selecting a suitable material for this experiment, tensile plates were made by the water jet from sheet metal for the tensile tests which were made on the university blasting device. The experiment compares the influence of corrosion degradation, in particular heat treatments. Hardness, corrosion and tensile strength tests during which also the values of acoustic emissions were recorded, are verified here. Pen test (Hsu-Nielson) was used for the activation of signal. The results of the measurements are supplemented by graphs from the course of the tensile test as well as by an acoustic emission record.*

Keywords*: mechanical properties, heat treatment, tensile test, corrosion*

INTRODUCTION

The purpose of the heat treatment of steels is in particular to achieve the mechanical and technological properties of material. This is a procedure in which the temperatures and chemical composition of metal are controlled. Unlike other engineering technologies, such as e.g. machining, forming etc., there is no change of the shapes of parts during the heat treatment (such a change is undesirable) but only required changes are achieved. There may be other positive effects during heat treatment but also negative effects [7]. The most often used as well as cheapest structural steels are wrought carbon steels. Technological properties (machining, forging, welding etc.) and needed mechanical properties (strength, tenacity, hardness etc.) are achieved usually in these steels only by chemical composition of steel, its forming and in a smaller scale also by its heat treatment [11]. Mechanical properties of carbon metals, in particular 12 Structural steels, can be greatly advanced by means of heat treatment. This steel class is distinguished by a higher purity and more advanced way of production [9]. Fe-C structural diagram describes basic parts of its composition. Austenite is a solid solution of carbon in iron, being located in the gama range at a temperature over 723 °C in the diagram. Austenite is tenacious, well cold formable, the maximum solubility of carbon is 2.06 % at a temperature of 1147 °C. [1]. Ferrite is the low-temperature modification of iron crystallising in body-centered cubic system. It has low strength and hardness, cold formable. Ledeburite is the eutectic mixture of austenite and cementite, being formed in alloys with the content of carbon over 2.14 %. Perlite is formed by the eutectic conversion of austenite into a mixture of cementite and ferrite, it is relatively formable and solid [12].

When annealing without recrystallization, the annealing temperature does not exceed the Acl temperature (except for soft annealing in hypereutectoid steels). Phase transformations are insignificant in this case. The proportion of cementite and ferrite in steel does not change, the concentration and division of lattice defects and the size of internal stress change [18]. Due to the recrystallization annealing in steels, the nodular properties are renewed, the elongated grains are removed and strengthened, new ferritic grains are formed and the abilities of plastic deformation after cold forming are renewed. The annealing temperatures are chosen in the interval 550 up to 700 °C, with a lag at this temperature being usually 1 to 5 hours. If a finer structure is requested, a lower annealing temperature is chosen, when using a higher annealing temperature, the grain becomes coarse [10]. The purpose of hardening is to increase the hardness of steel by creating an unbalanced structure. When hardening, a part is heated to the austenitizing temperature, after retaining at this temperature

followed by a cooling at a speed faster than the critical speed. The basic structure for hardened steels is the martensite or bainite structure. The required structures can only be achieved in steels with the content of carbon at least 0.3 %. [13]. Hardening can be divided into two main sorts according to the resulting structure – martensite and bainite hardening. Martensite is formed by the rapid cooling of austenite, it is a strongly saturated carbon solution in carbon α (ferrite). [5]. The time of retention at a given temperature does not depend only on the type of applied technology, but also on the kind of the used material and its thickness. The aim of the retention is to ensure in terms of time the course of all expected structural changes, e.g. transformation of the crystalline lattice, diffusion, dissolution, minority phases precipitation etc. Cooling decides on the final utility properties of the material and therefore it is considered to be the most important phase. The principal is to cool the material from the temperature at which it was being retained to the temperature of the environment. The very structure of material is influenced by the rate of the cooling [8]. The optimum hardening environment is such an environment which enables cooling of respective volumes at a rate exceeding only slightly the critical rate. An excessive cooling rate results in the increase of the level of temperature and structural stresses. The cooling environment should have optimally high cooling efficiency in the area of perlitic transformation and to the contrary a relatively low in the area of martensitic transformation. The cooling efficiency depends in particular on the thermal conductivity, the viscosity of the hardening medium and specific heat and heat of evaporation [4].

MATERIALS AND METHODS

ČSN 12 050 structural steel, suitable for annealing and tempering and surface hardening according to the ČSN 41 2050, was chosen for the experiment. It is a cold-rolled metal sheet for the thickness of 1.5 mm. The ČSN 41 2050 standard also limits the chemical composition of the semi-finished product. The tensile plates were made in Kovo Staněk s.r.o. The specimens were cut according to the drawing by the water jet from sheet metal of 1.5 cm thickness. The water jet must have been used for the production, as the use of laser would have caused undesirable thermal influence of the material. Each specimen was also marked in the upper right corner by stamping the appropriate number. All tensile plates were of the same dimensions and thickness so that the tensile test is performed on identical plates. A scheme of the tensile plate is shown in Figure 1.

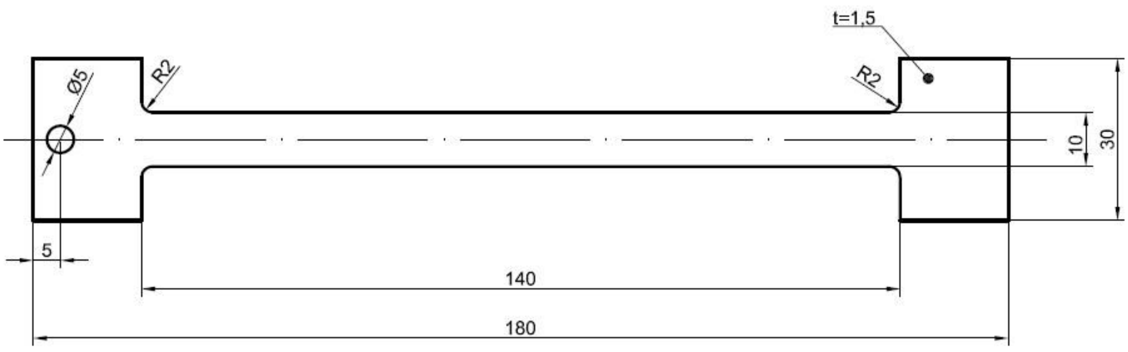

Fig. 1 Scheme of used tensile plate

The tensile plates were divided into four groups of five pieces. Subsequently, each group was thermally influenced by various ways. The hardness of the material was measured on all specimens after heat treatment. A part of the specimen from each group was exposed to accelerated corrosion conditions – salt mist. After 720 hours, test specimens were removed from the corrosion chamber and their weight loss in g×m^2 was determined. This was followed by the tensile test in all specimens, during which the recording of acoustic emission was

measured. Tensile strength Rm, contractions Z and elongation A have been determined using the tensile test. The dependencies of mechanical properties of the material on heat treatment and corrosion degradation were compared and evaluated at the end of experiment.

The tested material of 12 050 steel is suitable for hardening and annealing and tempering. For this reason, the below mentioned states of 12 050 steel (1.5 mm metal sheet) were included in the experiment:

1. 12 050.2 Recrystallization annealed (the delivered condition)
2. 12 050.4 Hardened
3. 12 050.6 Annealed and tempered to the lower strength typical for 12 050 steel
4. 12 050.8 Annealed and tempered to the upper strength typical for 12 050 steel

Heat treatment was conducted at the university electrical muffle oven MP05 – 1.1.

Prior to heating, a layer of the Kalsen agent was applied to the specimens. This agent prevents the undesired diffusion and oxidation processes taking place during the hardening, in particular decarbonisation of the upper layers of the specimen. The first group of specimens (10 pieces) was intended only for hardening. The specimens were placed to an oven heated for an austenitizing temperature of 850 °C with the retention of 5 minutes and subsequent rapid cooling in oil. The second group (5 pieces) was hardened in the same way. After a sharp cooling in the oil, the specimens were put again to the oven, now pre-heated for a temperature of 650 °C. The tempering lasted for 1 hour, followed by gradual cooling to ambient temperature. The last group of specimens (5 specimens) was also hardened, but this time tempered at the temperature of 450 °C, again with retention of 1 hour at this temperature and then it was gradually cooled to ambient temperature. A total of 5 HRC hardness measurements were conducted on each specimen. A predetermined number of thermally influenced specimens was placed to a corrosion chamber with a spraying solution of demineralised water and sodium chloride – neutral salt mist (NSS). According to the ČSN EN ISO 9227 standard, the following conditions of the test were kept in the corrosion chamber:

- Temperature: 35 °C ± 2 °C
- Salt solution concentration: 50 g/l ± 5 g/l
- pH value: 6.5 – 7.2

The tensile plates were placed to horizontal stands and put into the corrosion chamber. The stand with the specimens was placed into the chamber so that the specimens are not in the direct direction of the spraying of the spray and at the same time to avoid contact with the inner surface of the chamber or the surface of the adjacent specimen [17]. As recommended by the ČSN EN ISO 9227 standard, the duration of the test was set to be 720 hours during which check was performed regularly. During the tensile test, the record of acoustic emission was made on all specimens. Acoustic emission, hereinafter referred to as AE, belongs to the methods of non-destructive testing of materials. By means of DAKEL – XEDO diagnostic system is possible to analyse the acoustic signals during degradation. This system is an advanced device for capturing and recording of AE parameters, localization of AE sources, and signal sampling. Its main purpose is to monitor periodical tensile test to detect any potential hidden defects in primary circuit technology material and to identify locations that have the highest probability of material defect occurrence. [3]. For acquirement of unified impulses in each case of AE event the Hsu-Nielson pen test was utilized. AE waveguide construction (namely its shape, girth, acoustic conductance) significantly affects the output results in AE signal detection. Waveguides also increase the distance of sensor from signal source, which is also considered unfavourable. It is common in practical application, that installation of sensor directly to surface is impossible, e.g. inaccessible location on construction, or high temperature of measured surface (this is a most common cause of waveguide employment). However, there are certain cases, when employment of waveguide enhances the possibilities of signal detection - typically in structural engineering, namely firm

fixing of waveguide into a hole drilled in wood or concrete. Also fixing the waveguide to a plant for transpiration flow measurement in plant stem was conducted [14].

RESULTS AND DISCUSSION

The results of the hardness tests are shown in Table 1.

Table 1 The average measured hardness values

HARDNESS	
OIL HARDENED 850 °C/5 min I. set	Total average [HV]
Specimen No. 6, 7, 8, 9, 10	647,52
OIL HARDENED 850 °C/5 min II. set	
Specimen No. 12, 12, 13, 14, 15	667,88
TEMPERED 450 °C	
Specimen No. 1, 2, 3, 4, 5	356,92
TEMPERED 650 °C	
Specimen No. 16, 17, 18, 19, 20	207,76
RECRYSTALLISATION ANNEALED (the delivered condition)	
Specimen No.21, 22, 23, 24, 25	127,6

Weight loss results

The ČSN EN ISO 9227 standard states that the function of the test chamber is satisfactory if the weight loss of each steel or zinc specimen reaches the prescribed range. The recommended range of weight losses of steel specimens in the NSS test (neutral salt mist) amounts to 70 ± 20 [g · m−2] after 48 hours of the test. For

51 explored specimens, the average weight loss amounted after 48 hours to73, 66 [g· m−2].

Tensile tests' results

For the specimens hardened and tempered at a temperature of 450 °C, material hardness 357 HV and tensile strength of 1131 MPa were measured. The standard states a limit of tensile strength for this hardness amounting to 099 – 1147 MPa. For material hardness 210 HV, which was measured in specimens hardened and tempered at a temperature of 650 °C, the standard limits the tensile strength limit to 647 – 677 MPa, the tensile strength limit of 666 MPa was determined during the tensile test. The both tempering conditions under high temperatures (annealing and tempering) comply with the table values of the ČSN ISO 18265 standard. For recrystallization annealed material (the delivered condition), hardness of 128 HV and the tensile strength limit of 532 MPa were measured. The standard for this hardness in annealed condition states the tensile strength limit of 452 – 470 MPa. The higher measured tensile strength limit than specified in the standard can be explained by the fact that conversion of hardness to the tensile strength limit values is associated with high scattering. One of the reasons of the scattering in uncertainty which can be affected by the changes of microstructure ensuing from heat treatment or cold forming. The standard also specifies that the tensile strength limit table values are only approximate values that cannot replace the tensile test results. The course of the tensile test in specimen tempered at a temperature of 450 °C are shown in Figure 2.

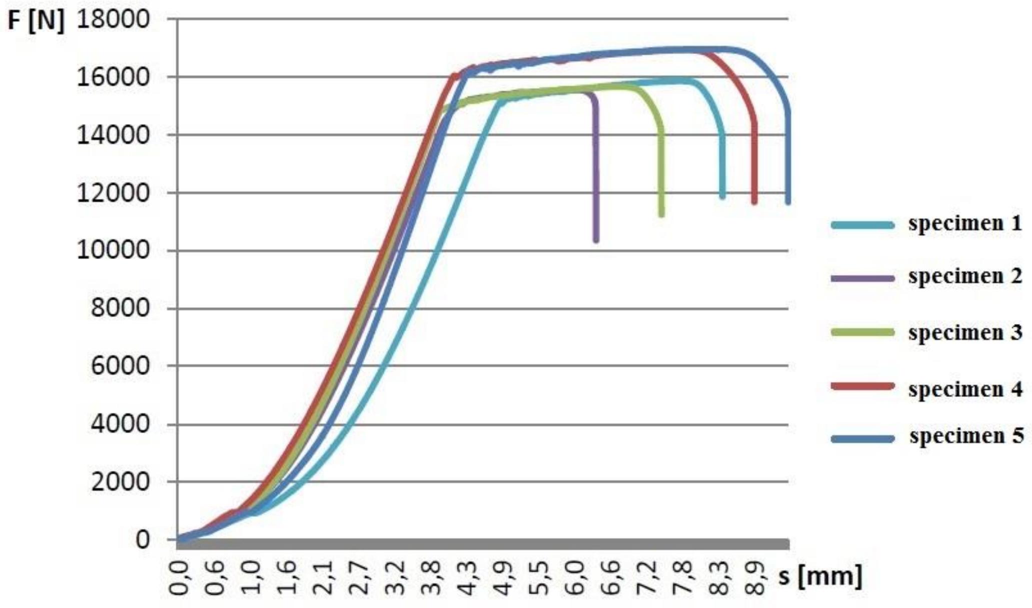

Fig. 2 The course of the tensile test. Specimens tempered at a temperature of 450 °C

The course of the tensile test diagram was in all specimens tempered at a temperature of 450 °C very similar. For tensile plates, there was measured almost the same tensile strength limit as for the hardened specimens was measured, but the tempered specimens achieved a more distinct elongation due to a higher toughness. The yield point is not recorded in the graph. It is more tough material, therefore it was necessary to develop a higher transformation work in order to divide the mass into two parts.

Acoustic emission measurement results

Figures 3, 4 show acoustic emission records during the tensile test in specimens No. 3 and 5.

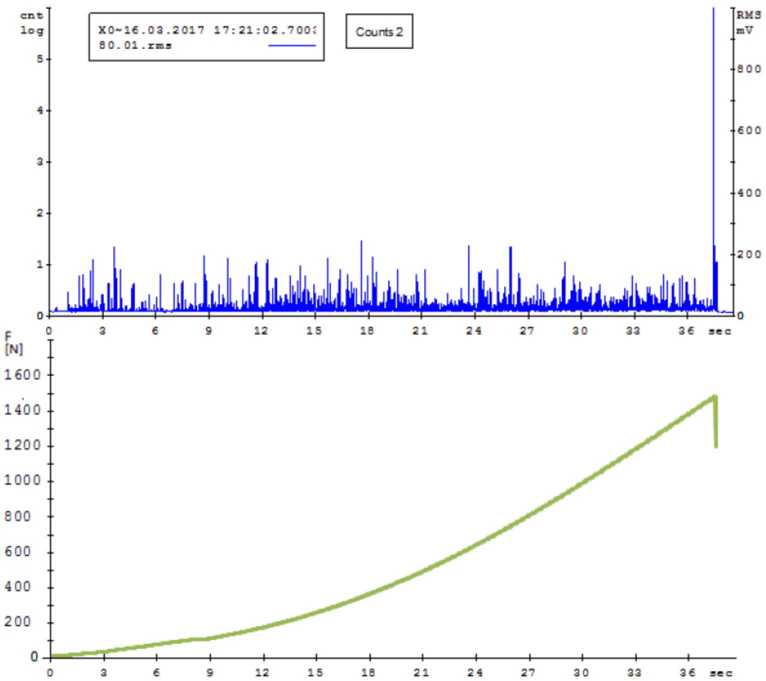

Fig. 3 Acoustic emission record of specimen 3 – oil hardened, austenitization time 5 minutes, exposed to aggressive corrosion environment

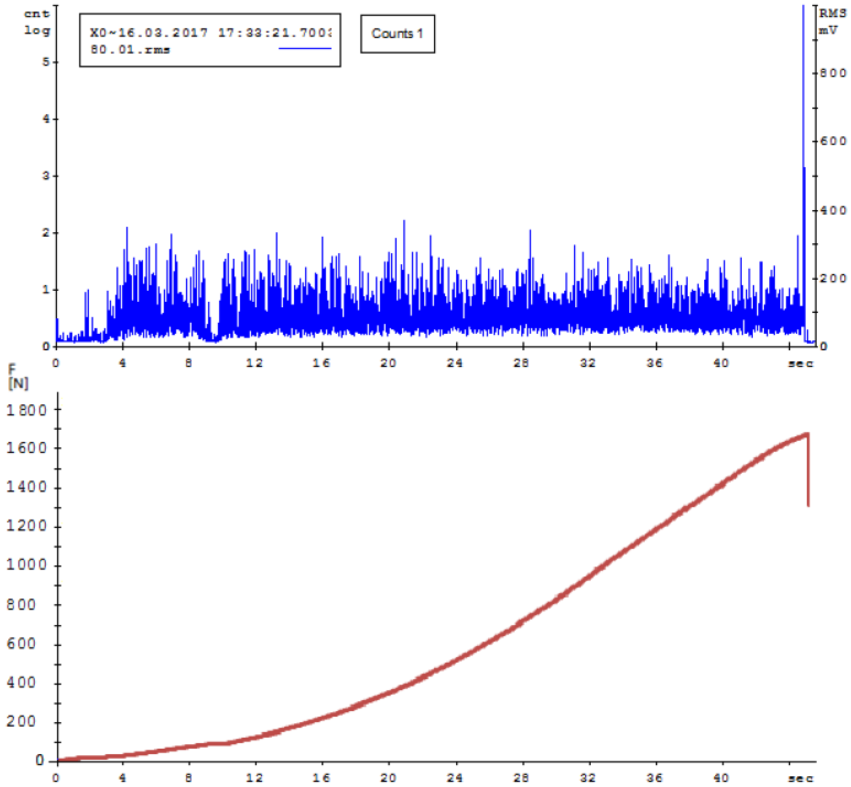

Fig. 4 Acoustic emission record No. – oil hardened, austenitization time 5 minutes

The AE record indicates that RMS designating the overall energy of the AE signal in tempered specimen No.3 exposed to aggressive corrosion environment (NSS) is considerably lower than in hardened specimen No.5 which is not degraded by corrosion. This phenomenon was manifested not only in hardened specimens with the time of austenitization of 5 minutes but also in other heat treatments. The lower overall energy of the AE signal in corrosion degraded specimens can be explained by the fact that the material has been already so degraded and all deformations have been absorbed by microcracks at corrosion pits and points. Intercrystalline and transcrystalline corrosion also disrupted the crystal lattice and caused cracks throughout and among the corns. All these undesirable processes caused a totally lower energy of the AE signal (RMS) in corrosion degradation specimen.

The literature Ptáček (2002) and Kraus (2013) defines that high temperature tempering (annealing and tempering) usually in the range 400 – 650 °C reaches optimum combination of strength, toughness and plasticity while decreasing hardness. The measured data confirm this definition. The specimens hardened and tempered at a temperature 450 °C retained the same tensile strength limit as specimens hardened while considerably decreasing hardness by 200 HV with an increase of toughness and plasticity. For samples tempered at a temperature 650 °C, the tensile strength limit was reduced to 500 MPa with a further decrease of toughness and plasticity.

Černý (1984) states that corrosion negatively affects the mechanical properties of material. This affirmation was confirmed by the performed corrosion test under the effect of neutral salt mist (NSS) lasting 720 hours. It has been also confirmed that steel 12 050 has a low corrosion resistance. The surface of the samples showed 100% degradation already during the first check after 168 hours. Determination of the weight loss did not prove that heat treatment would have a considerable influence on the course of corrosion.

As indicated by the Evans (2011) literature, in today's global competition with short life cycles of products and rapidly changing technologies, customers' demandingness, the companies can only remain competitive by producing quality products. The studies show that quality has a positive influence to financial performance.

CONCLUSION

This article includes a design of measurement methodology, the choice of experimental material, thermal exposure, the hardness test, corrosion degradation of specimens and tensile test supplemented by an acoustic emission record. Practical verification of the mechanical properties of 12 050 structural steel has proved after various heat treatment and corrosion degradation that the properties of this steel can be changed in a wide extent.

The work brings significant information about 12 050 steel in terms of heat treatment and resistance against corrosion. Due to its content and the experiment performed, the work can provide information for further research and application in technical practise.

In particular, an extensive database of knowledge about this material and verification of the influence of corrosion on the mechanical properties has been appreciated.

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CONTACTS

Petr Dostál, Department of Technology and Automobile Transport, Faculty of Agronomy, Mendel University in Brno Zemědělská 1, 613 00 Brno, Czech Republic, petr.dostal@mendelu.cz

Miroslav Prístavka, Department of Quality and Engineering technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, miroslav.pristavka@uniag.sk

Plamen Kangalov, Department of Repair and Reliability, Agrarian and Industrial Faculty, University of Ruse, 8, Studentska Str., 7017 Ruse, Bulgaria, e-mail: kangalov@uni-ruse.bg

Nela Poláková, Department of Technology and Automobile Transport, Faculty of Agronomy, Mendel University in Brno Zemědělská 1, 613 00 Brno, Czech Republic, nela.polakova@mendelu.cz

David Dobrocký, Department of Engineer Technologies, Faculty of Military Technology, University of Defence in Brno, Kounicová 156/65, 662 10 Brno, Czech Republic, david.dobrocky@unob.cz

Capability of the Measuring Equipment

Miroslav Pristavka, Hristo Beloev, Pavol Findura,
Lubomir Belan, Jan Marecek, Eva Krcalova

Abstract: *The aim of the article is to practically illustrate the methodologies and verify the capability of measuring equipment in the production organization. The methodologies have been shown in measuring station in the production process of the lid torque converter. The first method that we used was the study bias measurement system by which we acquired capability indexes Cgm, Cgmk. The resultant values of the capability indexes C_{gm} = 2,154 and C_{gmk} = 1,378 meet the eligibility requirements according to the measuring device C_{gm} ≥1,34, C_{gmk} ≥1,33. The second used methodology was the method of repeatability and reproducibility R&R, where we calculated the result % R&R = 27,7 %. It shows us that the value of % R&R is in the range of 10 – 30 % of the variance (or tolerance). The measuring system is conditionally suitable depending on the importance of application, cost of repair and gauge. Some corrective measures are needed depending on the use of the measuring equipment. As a measuring device, we used measuring station from the Marposs manufacturer.*

Keywords*: measuring, measuring process, capability of measuring equipment, quality*.

INTRODUCTION

The quality of measured data is one of the main pillars of quality assurance. It is necessary to meet the customer‘s requirements and satisfaction. As quality should be constantly improved along with rising customer demands, a functional quality assurance system must is needed in production organization [3,4]. It is therefore desirable that quality management would be focused on the whole life cycle of the product that the organization produces [7,10]. If we want to verify the capability of the production process, we must first verify the capability of the measuring devices. It would be unnecessary to find an error in the process if we have an inappropriate measuring device [9]. Therefore, it is necessary to verify the measuring equipment itself, ensure that the meter is used by skilled and trained workers and in the verification of the capability, include all the ambient influences that influence the measuring process [1,5].

To implement this method, it is necessary to follow certain guidelines:

- the measuring device must be set according to manual before the start of the test,
- during the test, the measuring equipment must not be installed,
- the reference piece must be removed from the measuring instrument after each measurement and re-inserted before the next measurement,
- the measurement should be performed in the same position and in the same location,
- the reference is measured by one operator at least 10 times.

When specifying the acceptable deviation value, unless otherwise stated in the documentation, it is recommended to specify 1.5% of the tolerance of the measured characteristic. This value corresponds approximately to the value of one R & R standard deviation at % R & R = 10% determined against tolerance [8,15].

MATERIAL AND METHODS

Capability indices of the measuring equipment

The procedure for calculating meter capability indices the C_{gm} and C_{gmk} is as follows:

- calculate the average of all measured values:

$$\bar{X}_a = \frac{1}{N}\sum_{i=1}^{N} X_i \qquad (1)$$

N – number of measurements
X_i = 1, 2, 3, ... N

− calculate the standard deviation:

$$s_w = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(X_i - \bar{X}_a)^2} \quad (2)$$

− capability indices C_{gm} a C_{gmk} are calculated according to the following patterns:

$$C_{gm} = \frac{0,2\,.\,T}{6s_w} \quad (3)$$

$$C_{gmk} = \frac{(X_r + 0,1T) - \bar{X}_a}{3s_w} \quad (4)$$

$$C_{gmk} = \frac{\bar{X}_a - (X_r - 0,1T)}{3s_w} \quad (5)$$

The minimum requirement for an eligible measuring device is:

− $C_{gm} \geq 1,34$

− $C_{gmk} \geq 1,33$

R&R repeatability and reproducibility

It is a combined value of the measurement system. We call it R & R (Repeatability and Reproducibility). Its statement in % relative to the variability of the measured samples or process to the specification is denoted as % R&R. Total variability is the process variability that is designed to evaluate the capability of the measurement system.

Long-term eligibility studies

We select a sample of 10 pieces that represent the actual (assumed) scattering of the process. Parts are numbered. We select three operators (A, B, C). Operators must be selected from employees currently serving the MP / MS. We let the operators measure all 10 pieces (not successive) and write down the measured values in the appropriate table (the record can not be made by the operator himself). We will use this procedure the next day - test # 2. On the next day we repeat the procedure for the third time - test # 3. The condition is that at least two tests must be performed [3,4].

Further we follow these steps:

a) We calculate the arithmetic mean of all values of the observed characteristic of test 1 of operator A. We will also repeat the calculation for other A operator tests.

b) We calculate the average of operator A: $\bar{X}_A$ and enter the value in the form.

c) Repeat the procedures in a), b) for operators B, C.

d) Minimal value from $\bar{X}_A$, $\bar{X}_B$, $\bar{X}_C$ je $\bar{X}_{Min}$ and maximal is $\bar{X}_{max}$.

e) We calculate $\bar{X}_{DIF} = \bar{X}_{MAX} - \bar{X}_{MIN}$ and enter the value in form.

f) We calculate the arithmetic mean of all values that were measured on sample 1 in all tests for all operators and enter the value in the form. We will repeat this procedure for other samples.

g) We calculate the range $\bar{X}_P$ samples from 1 to 10. It's a difference of maximum and minimum value.

h) We calculate the R range of the measured values on the first sample by operator A in all 3 tests. This is calculated as the difference between the maximum and minimum values. The range is also calculated for other samples.

i) We calculate arithmetic mean $\overline{R_A}$ of ranges. The mean $\overline{R_B}$, $\overline{R_C}$ is also calculated for operators B and C.

j) We calculate arithmetic mean $\bar{R}$ from the mean of $\overline{R_A}$, $\overline{R_B}$, $\overline{R_C}$.

k) We calculate the upper regulatory limit $UCL_R = D_4.\bar{R}$, where D4 is the constant shown in the table and is dependent on the number of tests.

l) We calculate the repeatability / variability of the EV device and the reproducibility / variability of the AV operator. Furthermore, we calculate the combined R & R repeatability

and reproducibility, sample variability and total TV variability. The value of total variability may be given: by the width of the tolerance field TV=USL-LSL or by the variability of the process for the observed characteristic $TV = 5{,}15.\sigma_{process}$ or by the samples variability $TV = \sqrt{\mathrm{R\&}R^2 + PV^2}$

m) We calculate the values in % : % EV, % AV a % R&R. Their sum is not 100%.

The acceptability level of the measuring instrument or measuring system

It is given by the percentage of repeatability and reproducibility (R & R) in total process variance (TV) or production tolerance (T) -% R & R::

- less than 10% of total scatter (or tolerance) - MP / MS is acceptable,
- 10-30% of total scattering (or tolerance) - MP / MS is conditionally acceptable depending on its importance, its price, repair costs etc., the decision to use belongs to the quality assurance manager of the relevant department,
- more than 30% of total scatter (or tolerance) - MP / MS is considered unacceptable and maximum effort should be made to improve it [5,7].

The production organization is engaged in the production of automotive parts and is the world's leading technology leader in drive and chassis technology as well as passive and active safety technology. The company is represented with approximately 135,000 employees in about 230 plants in 40 countries. It is one of the world's largest subcontractors in the automotive industry.

RESULTS AND DISCUSSION

Determination of capability of the measuring device in the process of producing the lid

Product characteristics

Due to the requirement of the production organization, we have chosen the production process for the production of the hydrodynamic torque converter. The part is shown in fig.1. The production drawings of the component are shown in figure 3. The lid is made of 16MnCr5 DIN EN 10084. For the verification of the measuring equipment capability, we focused on the characteristics of the production organization: ø 59.7 with tolerance -0.05 mm for the systematic error we measured on the calibration standard and the diameter ø 39.93 mm with tolerances + 0.020, -0.033 mm for repeatability and reproducibility measured on the finished product from the process. The Merlin Marposs digital measuring station is used to measure the dimensions of the lid in the production process [2].

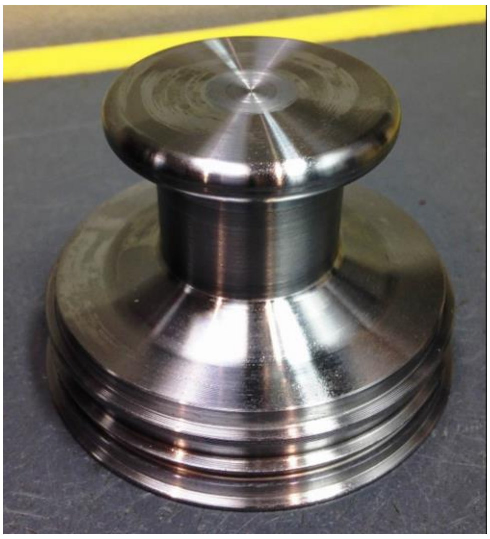


Fig. 1 Hydrodynamic torque converter

Fig. 2 Setting Standard

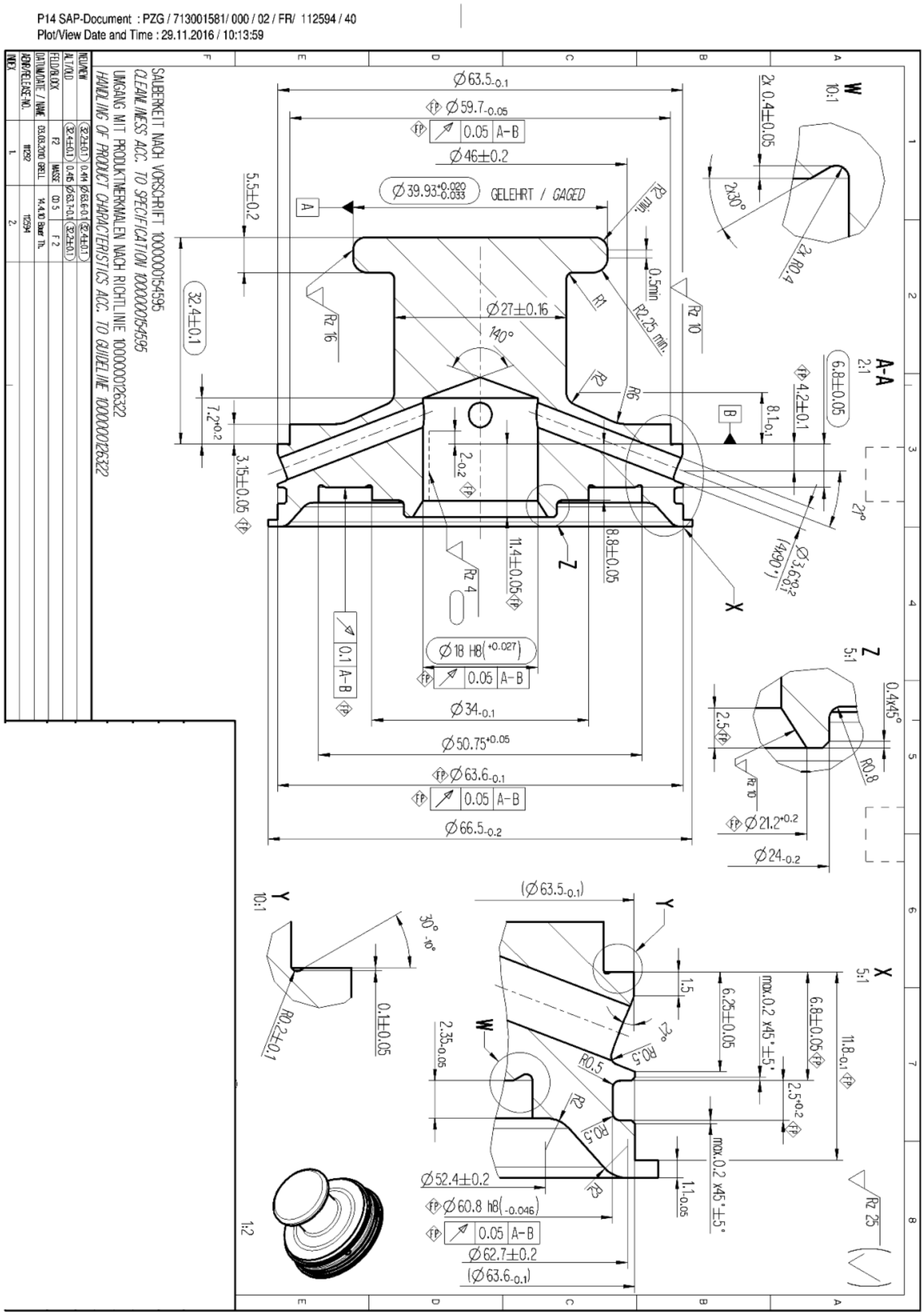


Fig. 3 The production drawings of the component

Characteristics of the measuring equipment

In the process of producing a torque hydrodynamic torque converter, a measuring station from the Marposs manufacturer is used, shown in Figure 4. The principle of measurement is by means of inductive sensors. The measuring sensors must be set to the calibration standard prior to any measurement. The sensor detects the reference value of the

standard that it compares with the measurement value during the measurement. The measuring station consists of: a measuring, display and evaluation unit. The measuring station has two-way control, to ensure safety of work. The measuring station is also used for statistical process control. It allows you to discover the causes of variability based on sample selection from the process [2].

Name of measure station: Marposs Merlin
Evidence number: LVCF17120
Resolution: 0,001 mm

Fig. 4 Measuring station Marposs Merlin

Characteristics of the standard
Designation: calibration standard 50046415 (fig. 2)
Evidence number: 713001581

- diameter: ø 39.926 mm,
- diameter: ø 59.677 mm,
- run-out: 0.003,
- diameter: ø 60.782mm,
- distance : 32.398 mm,
- distance: 6.804 mm,
- run-out: 0.002

Date of calibration: 29.11.2016 with validity of 12 months.

Determination of the measuring equipments indices

Table 1 Evaluation of the capability of the measuring equipment

STUDY OF THE SYSTEMATIC ERROR OF THE MEASUREMENT SYSTEM

Department:	**Quality and Engineering technologies**
Measuring system:	**Marposs Merlin**
num. of the meas. system:	
Process:	**the lid of a hydrodynamic converter**
Parameter:	**the diameter**
value	**mm**

Document:	**BIAST 1, 00110 SK**
Date:	**22.2.2017**
Responsible: **Ing. M. Prístavka, PhD.**,	

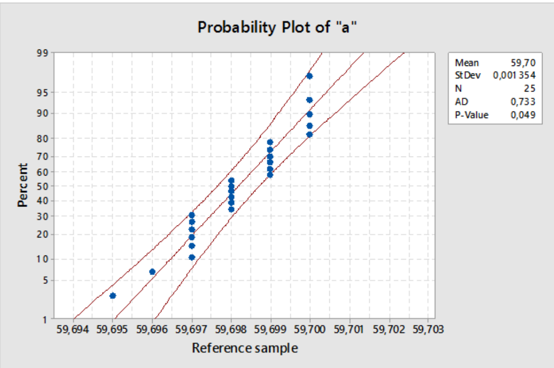
Description of the standard	**Reference value**	*59.7*
	The expanded uncertainty	*0.0014*

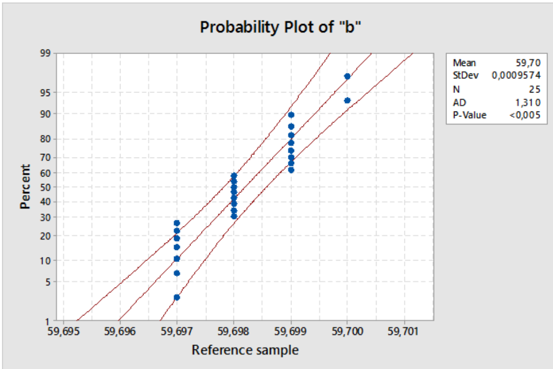
		a	b	c	d	e
Repeated measurements of the reference sample, mm	1	59.699	59.699			
	2	59.697	59.697			
	3	59.7	59.7			
	4	59.699	59.699			
	5	59.698	59.698			
	6	59.699	59.697			
	7	59.697	59.699			
	8	59.7	59.697			
	9	59.696	59.699			
	10	59.698	59.698			
	11	59.699	59.698			
	12	59.697	59.699			
	13	59.7	59.697			
	14	59.698	59.7			
	15	59.698	59.698			
	16	59.699	59.698			
	17	59.697	59.699			
	18	59.7	59.697			
	19	59.697	59.697			
	20	59.698	59.699			
	21	59.699	59.698			
	22	59.697	59.699			
	23	59.7	59.698			
	24	59.695	59.697			
	25	59.698	59.698			

Deviation		
1.0% of the measured		
	acceptable tolerance	0.597
	number of measurements	30
Product (process)	LTL	*59.65*
	UTL	*59.7*
	Tolerance (UTL-LTL)	0.05
The measurement of		
	number	50
The mean value of	average	59.6982
	LConfM	59.69787
	UConfM	59.69853
	deviation for repeatability	0.0011606
	% Repeatability	13.93%
expanded uncertainty of the value		
	The uncertainty [%]	0.23%
Analysis of systematic error		
Systematic error	The value	-0,0018
	% Toler.	3.60%
	LConfB	-0,002129832
	UConfB	-0,001470168
	breadthB	0,000659665
uncertainty interval	LConfU	-0,003238329
	UConfU	-0,000361671
	breadthU	0,002876657

Test of statistical hypotheses	Alfa	p-value	Significant?
Center value measurements = Ref. Value	0.05	<1E-04	Yes
System error = 0, takes account of the uncertainty.	0.05	0.0141	Yes

Cg, Cgk	**p=95,45%**	**p=99,73%**
Cg	2.1541011	1.4360674
Cgk	1.3786247	0.9190831





The results of the analysis	**Evaluation by the staff**
Suits for an acceptable variance = 0.597 (1.0% of measured)	The measuring equipment is capable

R & R repeatability and reproducibility

In this work, we decided (at the initiative of the production organization) to analyze a long-term eligibility study for determination of repeatability and reproducibility. The measurements were performed by three workers. With this method, we measured 10 serial products directly from the process and focused on the characteristic: diameter: ø 39.93 mm with tolerances + 0.020, -0.033 mm.

Table 2 repeatability and reproducibility R&R

REPEATABILITY AND REPRODUCIBILITY OF THE MS
(ANOVA method with interaction)

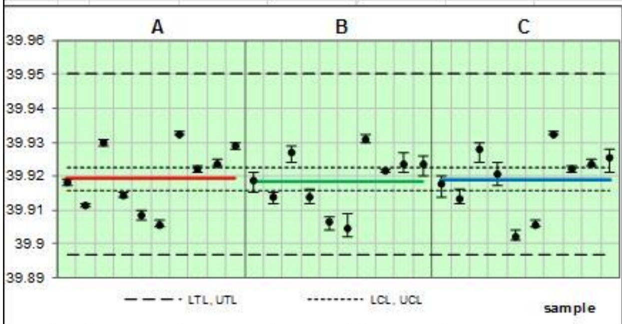
Department:	Quality and Engineering technologies			Document:	GRRA N 0112 SK
Measuring system:	Marposs Merlin			Date:	22.2.2017
number of the MS:					
Process:	the lid of a hydrodynamic converter	Responsible:		Ing. M. Prístavka, PhD.,	
Parameter:	average				
value	mm	Chart measurements:	S1		
		Note		The resolution of the	0,001
Operator (factor)	A			LTL	39,897
	B			UTL	39,95
	C			St. dev. of process	

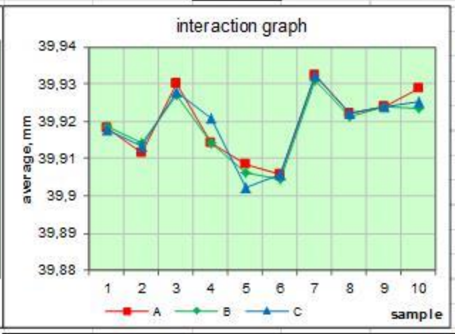
Sample		1	2	3	4	5	6	7	8	9	10	averages
A	1	39,919	39,912	39,931	39,915	39,91	39,907	39,933	39,923	39,925	39,93	39,9205
	2	39,919	39,911	39,93	39,914	39,908	39,905	39,932	39,922	39,923	39,928	39,9192
	3	39,917	39,911	39,929	39,914	39,907	39,905	39,932	39,921	39,923	39,928	39,9187
averages		39,91833	39,91133	39,93	39,91433	39,90833	39,90567	39,93233	39,922	39,92367	39,92867	39,91947
range		0,002	0,001	0,002	0,001	0,003	0,002	0,001	0,002	0,002	0,002	0,0018
B	1	39,921	39,915	39,929	39,916	39,908	39,902	39,931	39,922	39,927	39,92	39,9191
	2	39,92	39,915	39,928	39,912	39,904	39,909	39,93	39,921	39,921	39,924	39,9184
	3	39,915	39,912	39,924	39,914	39,907	39,902	39,932	39,921	39,923	39,926	39,9176
averages		39,91867	39,914	39,927	39,914	39,90633	39,90433	39,931	39,921333	39,92367	39,92333	39,91837
range		0,006	0,003	0,005	0,004	0,004	0,007	0,002	0,001	0,006	0,006	0,0044
C	1	39,92	39,916	39,93	39,921	39,904	39,907	39,933	39,923	39,925	39,928	39,9207
	2	39,914	39,912	39,929	39,917	39,901	39,905	39,932	39,922	39,923	39,921	39,9176
	3	39,919	39,912	39,924	39,924	39,902	39,905	39,932	39,921	39,923	39,927	39,9189
averages		39,91767	39,91333	39,92767	39,92067	39,90233	39,90567	39,93233	39,922	39,92367	39,92533	39,91907
range		0,006	0,004	0,006	0,007	0,003	0,002	0,001	0,002	0,002	0,007	0,004
averages		39,91822	39,91289	39,92822	39,91633	39,90567	39,90522	39,93189	39,921778	39,92367	39,92578	39,91897

	DF	SS	MS	F	p	Component	%proportion		
Sample	9	0,006653	0,000739	65,99813	<1E-04	8,09E-05	92,3%	UCLr:	0,008772
Operator	2	1,86E-05	9,3E-06	0,830266	0,4520	0	0,0%	Out of bounds margins:	0%
Interaction	18	0,000202	1,12E-05	2,495325	0,0043	2,24E-06	2,6%	UCLx:	39,92244
instrument	60	0,000269	4,49E-06			4,49E-06	5,1%	LCLx:	39,91549
Together	89	0,007143	8,03E-05		R&R	6,73E-06	7,7%	ver. of the outside limits:	77%
								Zero margins:	0%

NDC	PV	Process	Toler.
NDC	4		4
R/R	53		53
Stan. uncertainty of resolution			0,000289
The number of samples			10
The number of operators			3
The number of repetitions			3

	st. dev.	variability	%R&R TV	%R&R Process	%R&R Toler.
			Times: St. dev.		6
TV	0,009361	0,0561639			
PV	0,008994	0,0539651			
AV	0	0	0,0%		0,0%
Interaction	0,001496	0,0089749	16,0%		16,9%
EV	0,002119	0,0127122	22,6%		24,0%
R&R	0,002594	0,0155611	27,7%		29,4%





The results of the analysis	Evaluation by the staff
Suits conditionally	

CONCLUSION

The submitted contribution was addressed in production organization for the production of predominantly automotive parts where quality is a very important factor in both life and safety. Methodologies for verification of measuring devices used in this organization serve as universal methods for assessing the capability of meters at the output control as well as directly in the production process. These methods significantly contribute to the continuous improvement of the quality of the manufactured components and increase the competitiveness of the organization in the market.

Given that using the first measurement method, the measure station is capable and using the R&R method is partially capable, corrective action needs to be taken

As a corrective measure, we propose to change the calibration interval of the measuring station's sensors from a 12-month interval to a six-month interval as the liner production increased in the organization, extending the work on the line from two work shifts to three work shifts. This results in more manufactured products and thus more measurements.

ACKNOWLEDGEMENT

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CONTACTS

Miroslav Pristavka, Department of Quality and Engineering technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Slovakia, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, miroslav.pristavka@uniag.sk

Hristo Beloev, Department of Agricultural Machinery, Agrarian and Industrial Faculty, University of Ruse, 8, Studentska Str., 7017 Ruse, Bulgaria, e-mail: hbeloev@uni-ruse.bg

Pavol Findura, Department of Machines and Production Biosystems, Faculty of Engineering, Slovak University of Agriculture in Nitra, Slovakia, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, pavol.findura@uniag.sk

Ľubomír Belan, Department of Quality and Engineering technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Slovakia, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, xbelanl@is.uniag.sk

Jan Mareček, Department of Agricultural, Food and Environmental Engineering (FA), Mendel University in Brno, Zemědělská 1, 61300 Brno, Czech Republic, e-mail: jan.marecek@mendelu.cz

Eva Krcalova, Department of Agricultural, Food and Environmental Engineering (FA), Mendel University in Brno, Zemědělská 1, 61300 Brno, Czech Republic, e-mail: eva.krcalova@mendelu.cz

A Study of the Impact of Weld Overlay Speed on the Electrical Parameters of Vibroarc Weld Overlay in Argon on Worn Components of Transport and Agricultural Machinery

Mitko Nikolov,

***Abstract**: The paper studies the effect of weld overlay speed on the vibroarc process and its electrical parameters. The assessment criteria are the voltage of short circuit at the beginning and end of the arc; the size of the short circuit current at the end of the arc. The study is conducted by using a device for vibroarc weld overlay in argon with different electrode wires (Sv 08G of 2S, Np 30 HGSA, DUR 500) with a diameter of 1,6 mm. It was found out that weld overlay speed affects significantly the vibroarc process with minimal values of voltage and current magnitude being recorded at a weld overlay speed of 0,94 m/min. The evaluation criteria used in this study are the short circuit voltage at the beginning and end of the arc combustion and the magnitude of the short-circuit current at the end of the arc combustion. The study is conducted with the use of a device for vibroarc weld overlay in argon with different electrode wires (Sv 08G2S, Np 30 HGSA, DUR 500) with a diameter of 1,6 mm. It was found that the speed of welding affects significantly the vibroarc process where a welding speed of 0,94 m/min leads to minimal values of voltage and electrical current. .*

***Keywords**: Vibroarc weld overlay in argon,* speed of welding*, electrical parameters.*

INTRODUCTION

Argon is an inert gas, which protects reliably the arc and weld overlaid metal from the effects of oxygen and nitrogen in the air by providing high quality of repaired components. The formation of pores, oxides and nitrates, which increase the brittleness of the weld overlay, is reduced to zero. Vibroarc weld overlay in argon can be used to restore various, small and large - size components with simple and complex shapes, components with internal and external surfaces made of various metals and alloys [3, 4].

The speed of weld overlay is one of the main parameters of the vibroarc weld overlay procedure. This parameter determines the other kinematic and technological parameters of the electric arc process in weld overlay. To achieve high productivity, restoration has to be done at the highest possible speed of weld overlay, which provides quality vibroarc weld overlay coating. Weld overlay in a gas-protected environment can be done at a higher speed compared with other welding methods. By increasing the speed of weld overlay, we can reduce the weld penetration depth and layer thickness as well as the possibility of forming pores in the weld overlay metals [1, 3].

An increase in voltage leads to an increase in the arc interval, the time of the arc cycle, the burning of alloying elements and defects in the welded metals. An increase in the short – circuit current and particularly in the speed of this increase leads to increasing the heat – affected zone and spreading of electrode metal. The changes of these parameters with reference to weld overlay speed in vibroarc weld overlay in argon has not been researched enough [1, 2].

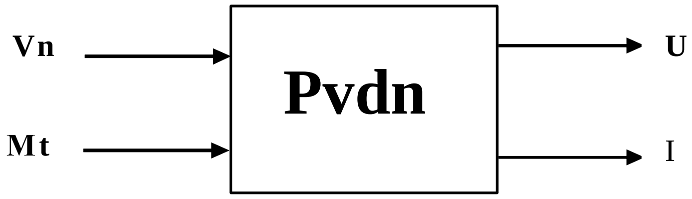

Fig. 1 A model for studying the process of vibroarc weld overlay in argon:
Vn is the weld overlay speed; Mt – the material of the electrode wire;
U – the voltage parameters; I – the parameters of current magnitude.

MATERIAL AND METHODS

The purpose of the study is to determine the effect of weld overlay speed on the electrical parameters of vibroarc weld overlay in argon. This is done by studying restored components of automobiles, tractors and other agricultural machinery by thoroughly researching the process of vibroarch weld overlaying in argon.

Research outline: The input parameters of the research model are as follows:

− Speed of weld overlay (Vn);

− Material of electrode wire (Mt).

− The basic criteria for evaluating the quality of the vibroarc weld-overlay process in carbon dioxide (Fig. 1) are:

− The voltage parameters (U), which include the short circuit voltage (Uks), the voltage at the beginning of the arc combustion (Und), and the voltage at the end of burning of the arc (Ukd);

− The parameters of the current magnitude (I), which include the magnitude of the electrical short-circuit current (Iks) and the current magnitude at the end of the electrical arc (Ikd).

The weld overlaying of the samples, used to study the influence of weld – overlay speed, was conducted by using a station for welding in shielded gases with the ENTON – 60 vibroarc apparatus, which is equipped with an axial non-inertial vibrator. The weld overlaying was performed on cylindrical, C45 samples with a diameter of 50 mm and a length of 250 mm. These dimensions correspond to the average dimensions and weight of the components that have to be restored [5, 6, 7]. On each sample we weld overlaid with different electrode wires (Sv 08G2S, Np 30HGSA, DUR 500) 5 layers with a width of 40 mm with a diameter of 1,6 mm. The weld overlay work mode was as follows: working voltage - 20 V; electric current - 150…180 A; vibration amplitude of the electrode wire - 2 mm; speed of feeding the electrode wire - 2,3 m/min; spacing between the weld overlay layers - 3 mm/tr; stick –out of the electrode wire - 15 mm; frequency of vibrations - 46,7 Hz and shielding gas consumption- 15 l/min. The speed of weld overlaying was changed gradually. Its values were 0,63, 0,94, 1,26 and 1,88 m/min.

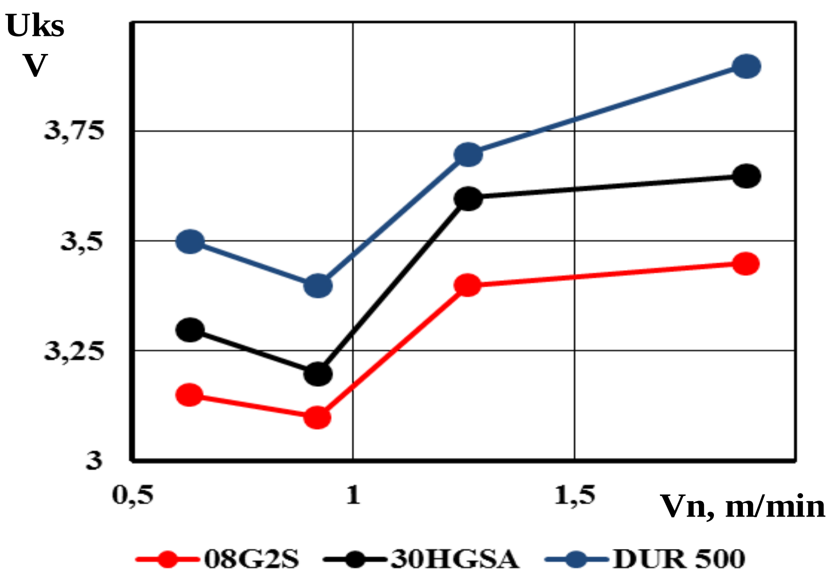

Fig. 2 Influence of weld-overlay speed (Vn) on the short – circuit voltage (Uks) in vibroarc weld-overlay in Ar with different electrode wires

The study of the vibroarc weld overlay process involves writing down and reporting the working voltage and electric current. The measurement and recording of the electric current in the supply chain of the vibroarc apparatus also involves the use of suitable shunts. The dynamics of changes in these parameters was recorded with an analog-to-digital converter produced by NATIONAL INSTUMENTS, мodel NI USB 6210. The process oscillograms were recorded in real time with the "Lab View" software. For each change in the amplitude of vibration and material of the electrode wire, we conducted 3 recordings and determined the average values of the output parameters. Recorded data were processed using Microsoft Office Excel. Obtained data concerning the electric parameters from the oscillography of the vibroarc process are processed with standard statistical methods.

According to [2], the voltage and magnitude of the electric current are of significant importance for the nature of the metal transfer process and the formation of the weld – overlay layer. Increasing the voltage leads to increasing the arc interval, the duration of the electric arc combustion cycle. It also affects the burning of part of the carbon and the alloying elements. Increases in the current affect mainly the geometrical parameters during the formation of the separate joints, the heat – affected zone and the degree of spreading of the electrode metal.

RESULTS AND DISCUSSION

The graphics, presenting the influence of weld – overlay speed on the electrical parameters of the vibroarc process, are created on after the statistical processing of data from the oscillograms of the process (Fig.2…Fig.6).

Fig. 2 shows the changes in the short-circuit voltage. Basically, the change of Uks is extreme. When the speed of weld – overlay is increased to 0,94 m/min the voltage is decreased for the three electrode wires. The most significant decrease is for the 30HGSA electrode wire. The smallest reduction of short –circuit voltage is recorded for the electrode wire 08G2S for 3,1 V, while the biggest reduction is for electrode wire DUR 500 for 3,4 V. When the values of the weld – overlay speed are higher, Uks increases and reaches values from of 3,45 V to 3,9 V for all electrode wires. This trend is preserved for all weld – overlay speed values and for a speed of 0,94 m/min the difference is the smallest, i.e. 0,3 V. Lower values of short – circuit voltage are a prerequisite for a less strong heat effect on the base metal. This in turn results in smaller welding penetration depth, smaller heat – affected zone and smaller deformations of components that are to be restored [1].

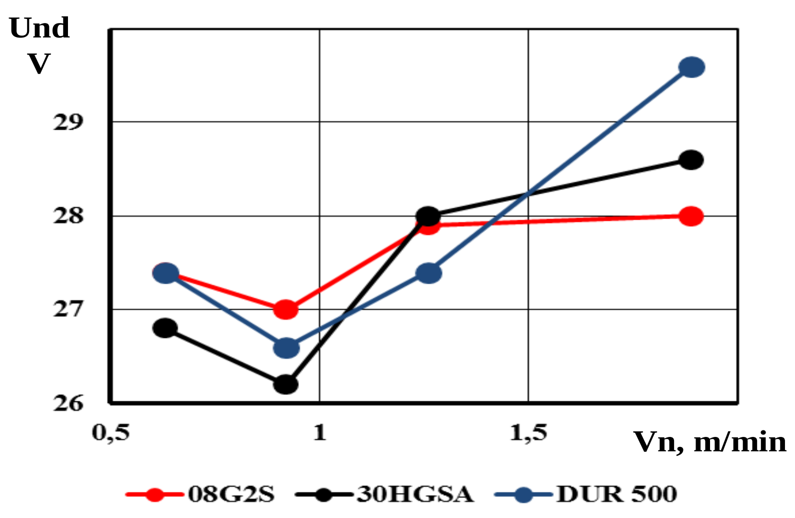

Fig. 3 Effect of weld overlay speed (Vn) on voltage at the start of arc combustion (Und) in

vibroarc weld overlay in Ar with different electrode wires

One of the most important parameters of vibroarc weld overlaying is the voltage at the beginning and end of the electric arc. The changes in voltage at the beginning of arc combustionare shown on Fig. 3. The graph reveals that the nature of voltage change (Und), as a function of weld – overlay speed, has a marked minimum at a speed of 0,94 m/min. After processing recorded data it was found out that voltage change at the start of arc combustions varies within a range of 26,8 to 29,6 V for the three electrode wires. At a weld – overlay speed of 0,94 m/min, the voltage values at the beginning of arc combustion for the three electrode wires are within very narrow boundaries of 26,2 V for the 30HGSA wire to 27 V for the 08G2S wire. The voltage values at the beginning of arc combustions at a weld – overlay speed of 1,88 m/min are much higher than the same voltage values at a speed of 0,63 m/min. This difference is the most pronounced for electrode wire 500, i.e. of 2,4 V. The increase of voltage of arc combustion leads to deterioration of the conditions for forming the weld – overlay layer and decreases the coefficients of welding and alloying. This is due to several factors: decrease in the degree of pre-heating of the electrode wire tip; higher degree of heat loss in the environment; increased length of the electric arc and higher degree of burning of the carbon and alloying elements. The reduction of voltage of arc combustion decreases the share with which the base metal participates in the weld – overlay layer. In addition, this decreases the cross section of the weld - overlay layer and allows for obtaining thin and evenly spread restorative coatings.

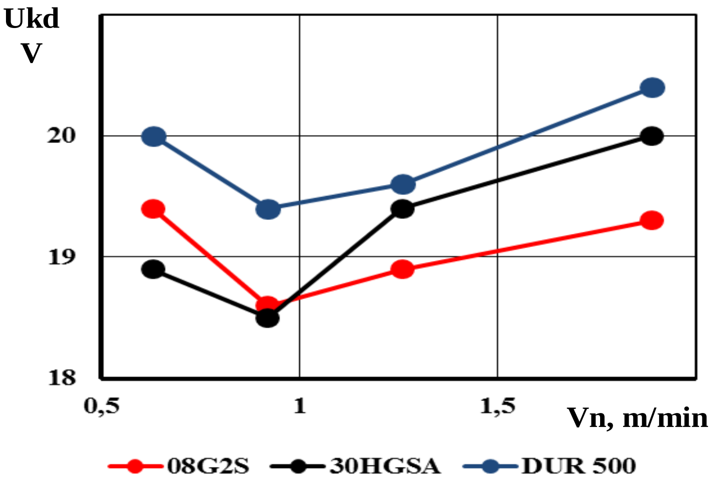

Fig. 4 Effect of weld overlay speed (Vn) on voltage at the end of arc combustion (Ukd) in vibroarc weld overlay in Ar with different electrode wires

The weld – overlay speed affects seriously the voltage at the end of arc combustion (Ukd). The change of this voltage as function of weld overlay speed has extreme nature. Its minimal values for each of the three electrode wires are obtained at a speed of 0,94 m/min (Fig. 4). The lowest voltage values of 18,5 V at the end of arc combustion are recorded for two of the electrode wires, i.e. Np 30HGSA and Sv 08G2S. The voltage values at the end of arc combustion at a weld overlay speed of 0,63 m/min and 1,88 m/min for the different wires is 1,5 V.

Table 1 Differences in voltage at the beginning and end of arc combustion

Electrode wires	Values of weld overlay speed Vn, m/min			
	0,63	0,94	1,26	1,88
08G2S	7,6	7,2	7,8	8,7
30HGSA	7,9	7,7	8,6	8,6
DUR 500	8,4	8	9	9,2

According to [3], the difference in voltage values at the beginning and end of arc combustion affects significantly the quality of the weld - overlaid coatings. The bigger the difference between voltage at the beginning and end of arc combustions, the higher the speed of cooling the metal. This also increases the risk of hot cracks. This is caused by the fast increase of inner tensions during crystallization of liquid phase. In addition, the process undergoes the so called temperature interval of embrittlement which encompasses the interval at the beginning of dendrites hardening until it reaches solid state. During this interval, metal is in a semi- liquid, semi – solid state and its ductility sharply decreases compared to its ductility in solid state. Under these conditions, the plastic deformation of metals is expressed through mutual displacement of crystals and their deformation. Since metal crystallization is accompanied by continuously changing inner tensions whose intensity increases with the lowering of temperature, crystals cannot withstand plastic deformation and they separate because of appearing cracks. Based on the conducted studies and the results presented in Table 1, we can conclude that this difference is the smallest at a weld – overlay speed of 0,94 m/min for the three electrode wires in the interval 7,2 … 8 V. The difference in voltage at the beginning and end of arc combustion in vibroarc weld overlay in argon is the smallest for electrode wire 08G2S. These values show that voltage values in the weld overlaid layer and the possibility of cracks in restoring components from tractors and other agricultural machinery by vibroarc weld overlaying in argon will be the lowest if we use the electrode wire 08G2S.

The short – circuit current and the current at the end of arc combustion depend significantly on the weld overlay speed (see Fig. 5 and Fig. 6). One of the main parameters of the electric arc process is the magnitude of short – circuit current. The value of this magnitude and particularly the speed of its increase have a serious impact on a number some aspects of the weld overlay process such as the heat – affected zone; the transfer of molten metal, its shaping and losses from spreading the electrode metal from the moment when the drop is detached from the tip of the electrode wire until it is transferred onto the metal surface the weld overlaid detail.

The changes of the short – circuit current is shown on Fig. 5. When the speed of weld overlay increases, the magnitude of short – circuit current (Iks) decreases considerably from 231…256 A to 205…224 A for the different electrode wires. It reaches a minimum at a weld overlay speed of 0, 94 m/min. If we continue to increase the speed until it reaches 1,88 m/min, the magnitude of short – circuit current increases significantly and its value is within the interval of 267…288 A. In weld overlaying with the medium carbon Np 30 HGSA electrode wire, the magnitude of the short – circuit current remains lower throughout the entire range of weld – overlay – speed change compared to weld overlaying with the low Sv08G2S and the high carbon alloyed DUR – 500 wires. The highest values (starting, minimal and end) of the short – circuit current are recorded in weld overlaying with the low carbon alloyed electrode wire Sv 08G2S.

The change of current at the end of the arc combustion Ikd has a marked extreme nature. The graph shows that the increase of weld – overlay speed affects seriously the

change of Ikd (Fig. 6). The lowest values for all three electrode wires are obtained at a weld – overlay speed of 0,94 m/min for the range of 117 - 132 A. The lowest current value at the end of the arc combustion is recorded for the DUR 500 electrode wire, i.e. 117 A. The current values at the end of the arc combustion for the three electrode wires fluctuate within narrow boundaries for the different weld – overlay speeds. The Ikd values for a speed of 0,94 m/min are considerably lower compared to the Ikd values for a maximum weld – overlay speed of 1,88 m/min. This difference is the most pronounced for electrode wire DUR 500, i.e. of almost 11 A.

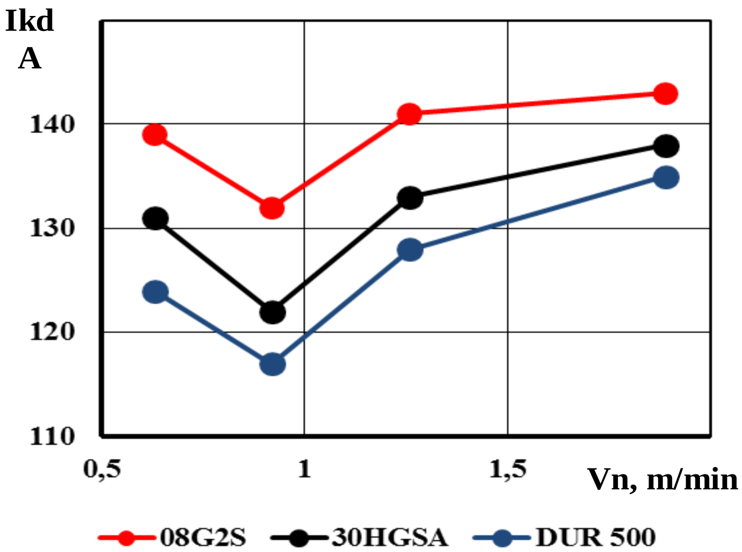

Fig. 5 Effect of weld overlay speed (Vn) on currency at the end of arc combustion (Ikd) in vibroarc weld overlay in Ar with different electrode wires

The difference in the short – circuit current values at the end of arc combustion, as well, for the particular values of weld - overlay – speed changes, affect the degree of heating of the base metal, the possibility for deformations in the weld-overlaid component and the uneven formation of weld-overlaid layer. The analysis of results shows that at a weld overlay speed of 0,94 m/min for the 08G2S electrode wire the difference in the values of Iks and Ikd is the smallest, i.e. 2 A. This is a prerequisite for a lower degree of heating of components and spreading of the electrode material. On the contrary, at a weld overlay speed of 1,88 m/min this difference is almost 7 times bigger, i.e. 15 A. This can lead to an increased spreading and burning of the electrode material as well as bad formation of the weld - overlaid metal, high roughness and danger of deformation of restored components.

CONCLUSIONS

− The speed of weld overlay affects significantly the vibroarc process and its electrical parameters (voltage and current magnitude) when the weld overlay is done in argon.

− The lowest voltage of short – circuit and arc combustion as well as short – circuit current at the end of arc combustion are achieved at weld – overlay speed of 0,94 m/min.

− Vibroarc weld overlay with electrode wire 08G2S in argon provides lower heat effect on the base metal; smaller deformations; lower voltage in the weld-overlaid layer. These parameters also decrease the possibility of cracks in the restored components of the tractors and other agricultural machinery.

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CONTACTS

Mitko Nikolov, Department of Repair and Reliability, Agrarian and Industrial Faculty, University of Ruse, 8, Studentska Str., 7017 Ruse, Bulgaria, e-mail: mnikolov@uni-ruse.bg

Quality Control by Quality Management Tools

Hristo Beloev, Vladimir Krocko, Maros Korenko, Plamen Kangalov,
Pavol Findura, Lubomir Belan, Jan Marecek, Eva Krcalova

Abstract: *This work describes the system of quality management and the method of its evaluation. The main part of this work is dedicated to monitoring quality of chosen product. "Carrier rear ARD91", which is made in organization Reydel Automotive Slovakia, in Nitra as a component for door panel, which is built in the motor car PSA Peugeot 208. The quality is now the most important factor of every organization for holding economic development and competition abilities. The final part of this study points out advantages of applying statistical methods of quality management in organization to ensure high quality of its products, reduce costs, economic growth and competitiveness in the market.*

Keywords: *quality, quality management system, regulation diagrams*

INTRODUCTION

The issue of production quality has now become a worldwide business phenomenon. The continual increasing demands of customers meant that besides the price of a product, quality is the most important factor in business. Not only is the quality basis for commercial success in the market, but it also carries overall business prosperity, because only the quality guarantees economically effective sale [3,9]. The current dynamic growth and rapid change of economic environment set a problem of ensuring long-term competitiveness for each organization. The decisive factor in a healthy market environment in relation with the customer is a marketing strategy based on advertising, product quality, prices, delivery terms, warranty terms, etc.. The decisive factor within the organization (internal environment) is a system and quality of organization management. This requires new methods of management and change in approaches to be put into practice. The basic objective is to increase efficiency, performance and product quality. Therefore, organizations introduce quality management systems [18]. When building a quality management system, the proposal and its adoption in management is important, but its implementation must be done from the root of the organization [15]. On the other hand, an organization that has a quality management system implemented is certified to the quality management system according to ISO 9001:2015, which demonstrates that it meets the requirements of not only the product quality but also for the manufacturing process [22].The aim will be to introduce statistical process control in the production process of a particular product by statistical methods in the organization Reydel Automotive Slovakia in Nitra. In the event of deteriorating quality or disagreement will be necessary to design effective measures to eliminate disagreements [4,13].

MATERIAL AND METHODS

Reydel Automotive Slovakia in Nitra has several manufacturing processes and distributes its products to several automotive organizations. Each type of product has its manufacturing process, which varies according to the requirements of a particular customer. In this paper we have chosen the manufacturing process of the right back carrier ARD 91 [14].

Gloss and colour check of a product is done by BYK – Gardner measuring device. AR91 carrier is a product used in the interior of a car, it is very important to maintain colour uniformity and therefore to perform control measurements gloss based on customer requirements.

Dimension check is among the most demanding inspection of a product. It is performed with a measuring agent onto which the product is fixed according to the procedure of the manufacturer and then measurement by micrometer is made. The measured values are entered into the control sheets, which are then analysed and evaluated [17].

Production of interior products for the automotive industry is extremely demanding on quality, production processes and compliance with all requirements of the customer. Statistical control methods enable tracing the process and based on the results assume its development [10].

Regulation diagram is used to set the process that will produce a product with a fixed measurable properties. The aim will be to apply regulation diagrams of an average ($\overline{x}$) and range *(R)* in the production process of AR91 carrier. We will monitor the dimensional control of carrier molding. Since the dimensions of the molding are determined by the customer, it is important to preserve them and keep within the tolerance limits [2,8].

We choose a number of subgroups. Based on the total number of measurements, we choose a range of a subgroup n=10.

We calculate an average value for every subgroup.

An average value of a figure in a subgroup:

$$\overline{X_i} = \frac{1}{n}\sum_{j=1}^{n} X_{ij} \qquad [1]$$

for i = 1,2,... k, and for j = 1,2,...

where :

i – subgroup serial number

j – serial number of value measured in a subgroup

k – number of subgroups

n – a range of a subgroup

X_{ij} – a value measured in a subgroup

A range in a subgroup:

$$R_i = MAX\ (X_{ij}) - MIN\ (X_{ij}) \qquad [2]$$

for i = 1,2, ... k, and for j = 1,2, ... n

where: $MAX\ (X_{ij}) - MIN\ (X_{ij})$ – maximum and minimum value measured in i-th subgroup.

Value of selective average is calculated according to the following formula:

$$\overline{\overline{X}} = \frac{1}{k}\sum_{i=1}^{k} \overline{X_i} \qquad [3]$$

Value of an average range is determined:

$$\overline{R} = \frac{1}{k}\sum_{i=1}^{k} R_i \qquad [4]$$

$\overline{X}_i$ a R_i are averages and range in i – th subgroups (i = 1,2, ... k)

$\overline{X}_i$ a R_i form central lines (CL) in regulation diagrams.

The width of a regulatory field is determined through upper and lower regulation limits for the average and range.

$$UCL_R = D_4 \cdot \overline{R} \qquad [5]$$

$$LCL_R = D_3 \cdot \overline{R} \qquad [6]$$

$$UCL_{\overline{X}} = \overline{\overline{X}} + A_2 \cdot \overline{R} \qquad [7]$$

$$LCL_{\overline{X}} = \overline{\overline{X}} - A_2 \cdot \overline{R} \qquad [8]$$

D_4, D_3 and A_2 – constants varying depending on the extent of sub-groups. Upper and lower regulatory limits are indexed as dashed horizontal lines in the table.

If we calculated the central lines and regulatory limits, we draw regulation diagrams. Their analysis shows that the process is under statistical control. We need to monitor that all points lie between the upper and lower regulatory limit [16].

As in any of the following situations, the process is not under statistical control. The manufacturing process must be stopped, investigated and preventive or corrective action has to be done. If none of the above situations occurs, we can conclude that the process is under statistical control [19].

RESULTS AND DISCUSSION

Visteon is the fourth largest supplier of automotive parts in the world. Its operations are focused on the manufacture of interiors, climate and electronics for major automotive organization. The organization has two zones for plastic moldings injection, four mounting areas manufacturing finished parts for the customer and two paint shops. We focused on the quality assessment of "The rear right carrier ARD 91", which is produced at the injection press for plastic products of Krauss Maffei. ARD rear carrier 91 is produced as a component of ARD door panel 91 which is supplied to the customer of PSA Peugeot Citroen in Trnava [23].

AR 91 rear carrier is an interior part and should be monitored for colour uniformity of the product and also its gloss. Gloss is controlled according to customer requirements based on standard (Fig. 1) according to which we set the BYK – Gardner apparatus.

Fig. 1 Standard for gloss check

The tolerated value is 1.7±0.5 mm (Fig. 2). Gloss check is carried out by quality inspector. There are precisely targeted spots on the product where measurements are necessary. The measurement procedure is developed according to customer requirements.

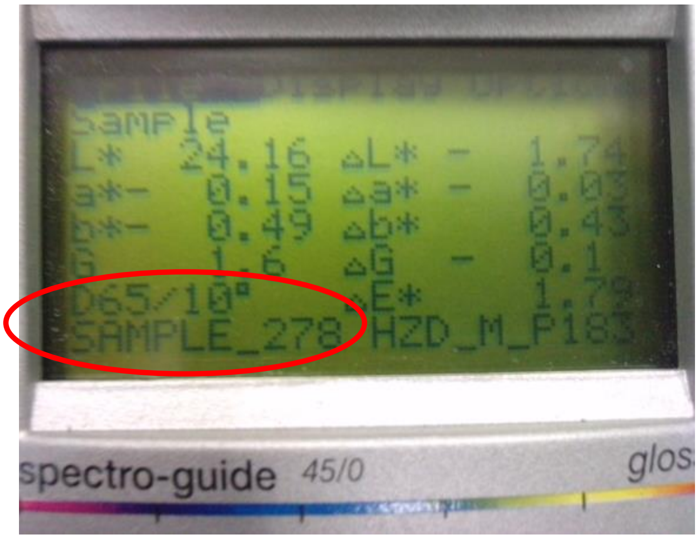

Fig. 2 Correctly measured value of gloss

Dimension check is performed on the measurement agent that is undertaken by the worker of quality at each production run or when halting the machine because of a fault (Fig. 3).

Fig. 3 ARD 91 rear carrier clamped in a measurement preparation

Records of calibration of the instrument are in a possession of a laboratory technician and the scale is labelled with a validity of the calibration. Samples of injected "ARD 91 rear carriers" were taken at 10 minute intervals. After two hours of cooling in the natural environment (production plant), the measurements were done. Since the carriers are prescribed with three measuring points, we have chosen dimensional control of the measuring point. This point has, according to the customer's requirements tolerance of 1.0 ± 0.7 mm. The spot refers to the carrier height in the *z* axis. According to the results of measurements, it is clear that all the measured values are within tolerance, but it is not possible to estimate the process regulation and highlight variations in the manufacturing process. Using statistical methods in organizations improve the effectiveness and efficiency of production processes. Subsequently, we calculated the average value of the whole process ($\bar{X}$) and the value of the range ($\bar{R}$) that form a central line in regulation diagrams (Tab.1).

Table 1 Measured values of ARD 91 Rear carrier

Serial number	Measured values, mm										$\overline{X}$	R_i
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}		
1.	0.93	1.02	1.17	1.28	1.10	1.19	1.12	1.15	0.90	1.23	1.11	0.38
2.	0.92	1.04	1.27	1.04	1.09	1.18	1.25	1.30	1.00	0.85	1.09	0.45
3.	0.90	1.23	1.17	1.09	0.94	0.93	1.43	0.99	1.05	1.14	1.08	0.53
4.	0.87	0.94	1.17	1.31	1.08	1.06	1.29	1.26	1.29	1.03	1.13	0.44
5.	1.06	1.19	1.27	1.20	1.29	1.19	1.23	0.92	1.20	1.06	1.16	0.35
6.	1.09	1.24	1.29	1.27	1.03	1.22	0.92	0.87	1.26	1.30	1.15	0.43
7.	1.39	1.32	1.26	1.31	1.36	1.23	1.13	1.23	1.18	1.00	1.24	0.39
8.	1.07	1.13	1.25	1.33	1.23	1.36	1.11	0.96	1.07	0.98	1.15	0.40
9.	0.94	1.06	1.43	1.36	1.24	1.14	1.07	1.32	1.36	1.34	1.23	0.49
10.	1.04	1.08	1.25	0.99	0.96	1.24	0.94	1.29	1.17	1.22	1.12	0.35
11.	1.04	1.49	1.28	1.42	1.24	1.24	1.19	1.17	0.94	1.17	1.22	0.55
12.	1.18	1.05	1.27	1.01	0.94	0.82	0.99	1.08	1.09	1.24	1.07	0.42
13.	1.24	1.00	1.23	1.30	1.27	1.40	1.24	1.36	1.16	1.23	1.24	0.40
14.	0.94	1.11	1.00	1.12	0.85	0.97	0.92	1.34	1.03	1.09	1.04	0.49
15.	1.26	1.14	0.96	1.17	1.28	0.96	0.93	1.12	1.26	1.00	1.11	0.33
16.	1.08	1.37	1.33	1.07	1.16	1.16	0.95	1.40	1.14	1.25	1.19	0.45
17.	1.17	1.09	1.30	0.96	1.13	1.23	0.95	1.17	1.19	0.95	1.11	0.35
18.	1.09	1.28	1.19	1.00	1.12	1.19	1.23	1.21	0.89	1.07	1.13	0.39
19.	0.93	0.98	0.94	1.17	1.30	1.09	1.19	1.17	1.21	1.24	1.12	0.37
20.	0.96	1.23	1.18	1.29	1.25	1.14	1.07	1.23	1.00	0.91	1.13	0.38
21.	0.97	0.96	1.23	1.32	1.20	1.07	1.34	0.99	0.98	1.24	1.13	0.38
22.	1.35	1.30	1.26	1.07	1.12	1.08	1.02	1.14	1.26	1.33	1.19	0.33
23.	1.24	1.23	1.36	1.26	1.24	1.32	1.25	1.17	1.03	1.24	1.23	0.33
24.	1.24	1.30	1.24	1.09	0.94	0.90	1.07	0.96	0.98	1.27	1.10	0.40
25.	1.23	1.06	1.14	0.96	0.88	1.05	1.14	1.23	1.05	1.26	1.10	0.38
											$\overline{\overline{X}}$ =1.14	$\overline{R}$ =0.42

We indexed all of the values calculated in a graph and created diagrams for $\overline{X}$ - diagram for average and created diagrams for R-diagram for range (Fig. 4).

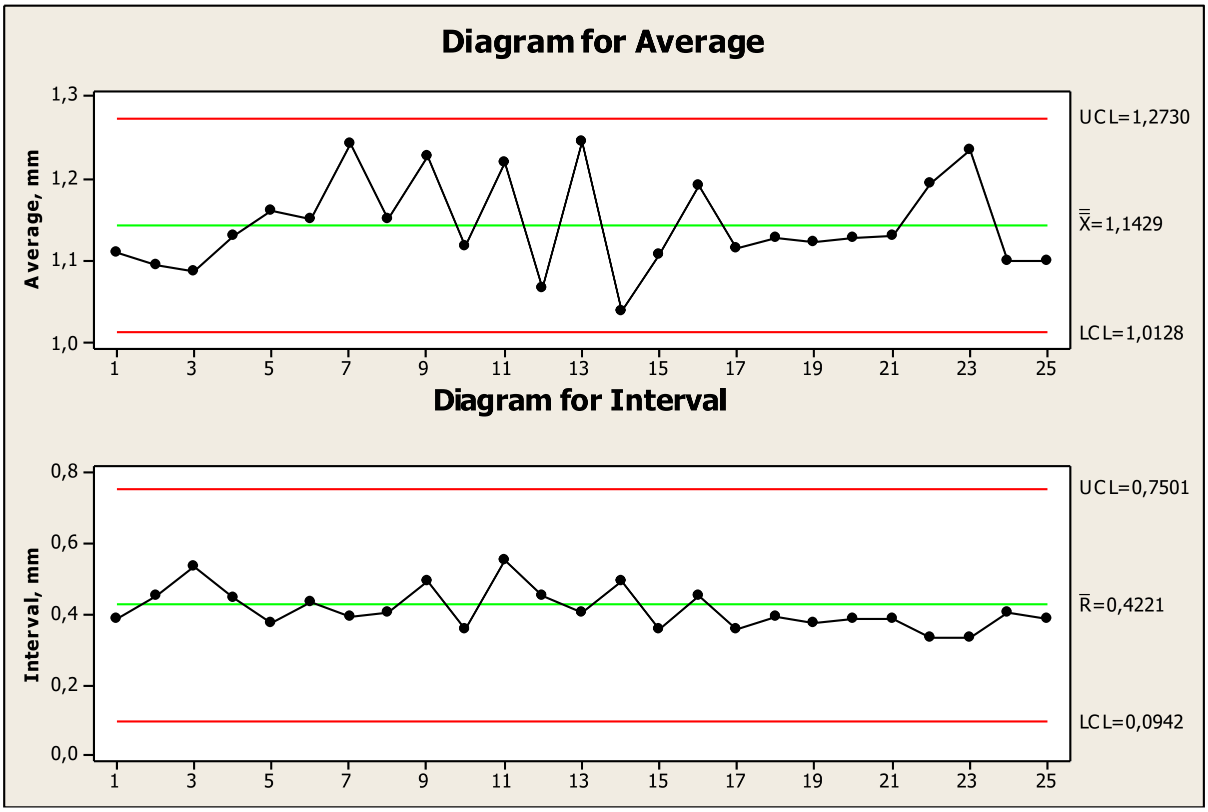

Fig. 4 Regulation diagram for average and range

CONCLUSION

Implementation and monitoring of quality in all processes must be perfectly designed, understood and monitored. Introducing statistical regulation of process should help to reinforced monitoring of production process. Therefore, organizations are turning to quality management systems, which are aimed at defining processes and production methods. All employees in all positions try to carry out their work in accordance with quality requirements in order to satisfy customer's requirements and thus meet the aim of the organization. Gloss check of a product carried by the BYK – Gardner measuring apparatus is a very accurate method of ascertaining the eligibility of production in terms of customer's requirements for colour and gloss uniformity of the product. By introduction of statistical methods in the production process, we can monitor the quality of the production process and the product itself. Therefore, using regulation diagrams for the average ($\overline{X}$) and range (R), we monitored the production process of the ARD 91 Rear carrier. Based on the analysis of these regulation diagrams, we found that while the process is under statistical control, the values they have indicate that the manufacturing process of ARD 91 Rear carrier has a fluctuating nature. Regulation diagrams should be implemented in the production process so that a production progress would be easily viewed and predictable. Their introduction would made the organization even more effective and would still possibilities for improvement.

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CONTACTS

Hristo Beloev, Department of Agricultural Machinery, Agrarian and Industrial Faculty, University of Ruse, 8, Studentska Str., 7017 Ruse, Bulgaria, e-mail: hbeloev@uni-ruse.bg

Vladimir Krocko Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak republic, e-mail: vladimir.krocko@uniag.sk

Maroš Korenko, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak republic, e-mail: maros.korenko@uniag.sk

Plamen Kangalov, Department of Repair and Reliability, Agrarian and Industrial Faculty, University of Ruse, 8, Studentska Str., 7017 Ruse, Bulgaria, e-mail: kangalov@uni-ruse.bg

Pavol Findura, Department of Machines and Production Biosystems, Faculty of Engineering, Slovak University of Agriculture in Nitra, Slovakia, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, pavol.findura@uniag.sk

Ľubomír Beláň, Department of Quality and Engineering technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Slovakia, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, xbelanl@is.uniag.sk

Jan Mareček, Department of Agricultural, Food and Environmental Engineering (FA), Mendel University in Brno, Zemědělská 1, 61300 Brno, Czech Republic, e-mail: jan.marecek@mendelu.cz

Eva Krcalova, Department of Agricultural, Food and Environmental Engineering (FA), Mendel University in Brno, Zemědělská 1, 61300 Brno, Czech Republic, e-mail: eva.krcalova@mendelu.cz

Analysis the Factors Affecting Conveyance Rate of Unbucket Chain Trenching Machine

Doan Dinh Diep

Abstract: *Analysis the process cutting soil of chain trencher has been developed. The performance of a chain trencher is expressed by its production (excavation) rate . The production rate, i.e, the volume of soil excavated per hour, affects the time necessary to excavate a trench. For a given conditions of digging soil, there are several factors affect performance rate of chain trenching machine relate to cutting depth of trench d; cutting wide of trench W, cutting angle Φ; longitunal tooth spacing S; tangential tooth speed* u_t *and traverse speed U. This paper deals with theoretical study the factors affecting conveyance rate of chain trenching machine, relationship between volume accumulated soil cuttings and volume available for one complete interval between tracking teeth and use it to lay out the cutting teeth on cutting assembly of Russian digging machine PZM-2 so that to ovoid the phenomenon of squeezing soil.*

Keywords: *chain trenchingmachine, performance, conveyance rate.*

INTRODUCTION

Chain trencher is a machine that uses a rotating cutting chain equipped with teeth to excavate trenches for underground cables and pipelines. When a chain trencher's digging a trench, its teeth produce cuttings throughout theirs working sweep, and the working chain is almost used as a conveyor to remove accumulated soil cuttings simultaneously. The rate accumulated soil cuttings by the teeth may be more, equivalent or less than a conveyantcapablity of working chain. When rate accumulated soil cuttings by the teeth is more than a conveyant capability of working chain, the accumulated soil cuttings begins to squeeze, harden and causesdifficulty to clear the soil. The soil remains on the chain, comes back to the working face and the consequences of that cause reduction productivity of chain trencher. This situation is called phenomenon of queezing soil.

EXPOSITION

CHAIN TRENCHING MACHINE AND ITS CUTTING ASSEMBLY

The cutting assembly on a chain trencher machine usually consists of a maneuverable cantilever support member that carries the working chain and its guides. The endless chain that carries cutting teeth to cut the soil from working surface. The cutting tools on endless chain are laid out in a repeating pattern that is symmetrical about the center line of the chain face. The free end cutting assembly is known as the nose. The nose is usually the trailing end of the cutting assembly. The sprocket at the nose, which normally is not driven, is the nose sprocket [1, 2, 5].

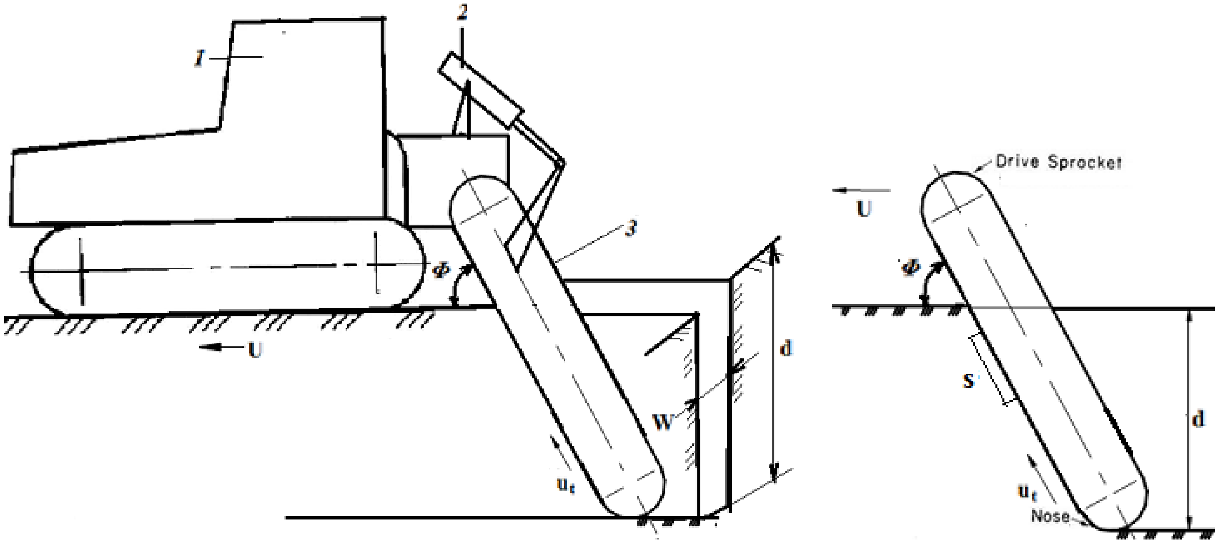
When chain trencher machine is trenching, the machine is normally operated with the drive sprocket clear of the work and rotating so as to pull the active side of the working chain towards itself in tension(Figure 1). The chain tends to convey cuttings to the free surface, and to pull the cutting assembly into the work surface. The angle Φ, can vary by the hydraulic cylinder 2, but it is commonly less than 90^0 [11]

CHIPPING DEPTH

When a chain of chain trenching machine is cutting soil under typical conditions, as in Figure 2, each tooth enters the work face at point A with a cutting depth h^{AB} that is close to zero; transient values of h^{AB} then increases steadily through the curved portion of the nose AB, until it reaches the steady maximum value cutting depth h that will be maintained throughout the rest of working sweep to the free surface [3].

The transient values of h^{AB} can be determined:

$$h^{AB} = \frac{U}{u_t} S \sin\theta \tag{1}$$



a) **b)**

Fig. 1 a) chain trenching machine and b) cutting assembly

1 – truck carrier; 2 – hydraulic cylinder; 3 – cutting assembly; d – cutting depth;
W – cutting wide; Φ - cutting angle; S – longitunal tooth spacing; ut - tangential tooth speed;
U - traverse speed

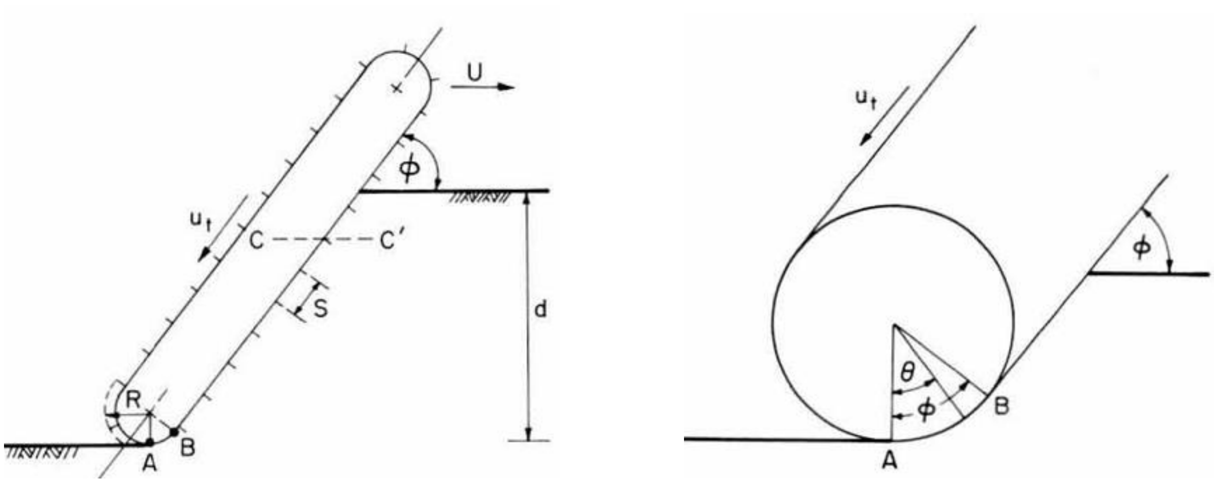


Fig. 2 Symbols used in working chain analysis:
S – longitunal tooth spacing; R – nose radius

When the swept angle of the nose sprocket θ reaches the exit cutting angle *Φ*. h^{AB} reaches its maximum value h .

Deriving the value of h directly from consideration of the motion of the straight part of the cutting assembly, it can be seen that cutting depth h is determined by the forward

movement of the machine at speed U during the time interval Δ_t between successive tooth passes through a given horizon such as C-C' in Figure 2. If the tangential tool speed is u_t and the lineal spacing between tracking cutters is S, then $\Delta_t = S/u_t$. In this same time interval the traverse motion gives the whole cutting assembly a horizontal displacement of ($U\Delta_t$), so that the horizontal penetration of the tooth is (SU/u_t). The theoretical cutting depth h, which here is taken to be cutting penetration normal to the face of the working chain, is thus

$$h = \frac{U}{u_t} S.\sin\emptyset, \tag{2}$$

Which is identical to the limit value of eq1. Equation 2 is shown graphically in Figure 3 for typical values of U/u_t.

For a chain trenching machine operating at set values of U, u_t and S, cutting depth as a function of cutting angle Φ and the theoretical maximum cutting depth h_{max} occurs with cutting angle $\Phi = 90^0$:

$$h_{max} = \frac{U}{u_t} S \sin\phi_{max} = \frac{U}{u_t} S \sin 90^0 = \frac{U}{u_t} S, \tag{3}$$

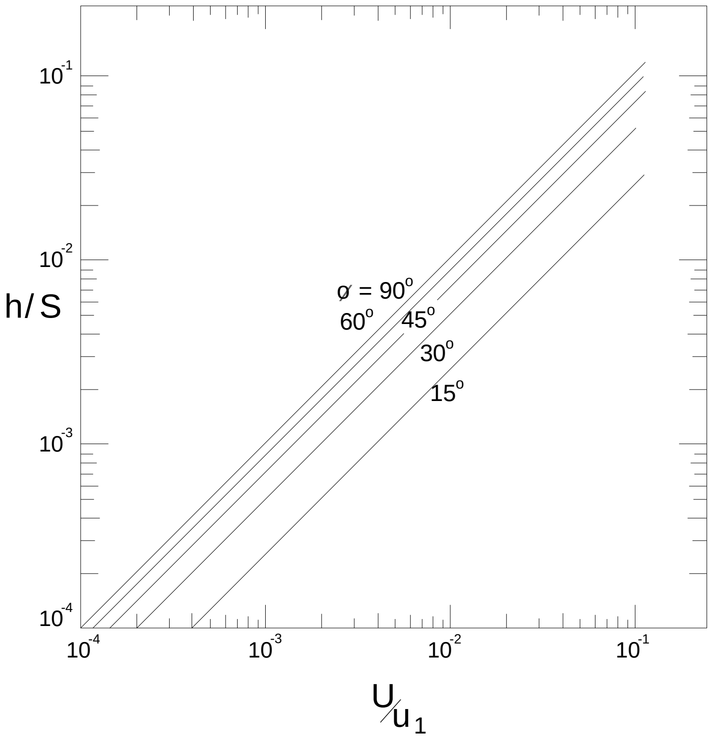


Fig. 3 Plot showing cutting depth h as a functionof tangential tooth speedut , traverse speed U, longitunal tooth spacing S and cutting angle Φ

PERFORMANCE OF CUTTING

Processes cutting by teeth and conveying by chain of chain trenching machine are co-occurrent. Each tooth produces cuttings throughout its working sweep, and the working chain is almost invariably used as a conveyor to remove accumulated soil cuttings.

For the width of the working chain W, the approximate in-place volume of soil cut by the chain at rounded nose of cutting assembly Q_n can be obtained by integration of eq 1:

$$Q_n = \int_0^{\theta \max} Wh^{AB} R d\theta = RS \frac{U}{u_t} \int_0^{\theta \max} \sin\theta d\theta = WRS \frac{U}{u_t}(1 - cos\emptyset), \qquad (4)$$

For the width of the working chain W, the approximate in-place volume of soil cut by the chain at along the straight section of the cutting chain (Q_b) is

$$Q_b = Wh\left[\frac{d}{sin\emptyset} - R(1 - cos\emptyset)\right] = \frac{WRSU}{u_t}\left[\frac{d}{R} - sin\emptyset(1 - sin\emptyset)\right], \qquad (5)$$

The total the approximate in-place volume of soil cut by the chain (Q_c) is thus

$$Q_c = Q_n + Q_b =$$

$$= \frac{WRSU}{u_t}(1 - cos\emptyset) + \frac{WRSU}{u_t}\left[\frac{d}{R} - sin\emptyset(1 - sin\emptyset)\right] =$$

$$= \frac{WRSU}{u_t}(1 - cos\emptyset) + \frac{WRSU}{u_t}\left[\frac{d}{R} - sin\emptyset(1 - sin\emptyset)\right] =$$

$$= \frac{WSdU}{u_t}\left[1 - \frac{R}{d} sin\phi(1 + cos\emptyset - sin\phi)\right], \qquad (6)$$

With a long cutting assembly and small nose radius

$$\frac{R}{d} sin\phi \ll 1 \text{ and } \frac{R}{d} cos\phi \ll 1 \qquad (7)$$

And therefore

$$Q_c = \frac{WSdU}{u_t}, \qquad (8)$$

Marking K_b is a bulking factor, the actual volume of cutting $Q_c^{'}$ from the in-place volume $v_c$is thus:

$$Q_c^{'} = K_b Q_c = K_b WSd \frac{U}{u_t}\left[1 - \frac{R}{d}\sin\phi(1 + \cos\phi - \sin\phi)\right] \qquad (9)$$

ADEQUATE PROVISION TO AVOIDE PHENOMENON OF SQUEEZING SOIL

Since the chain is acting as a conveyor, there must be sufficient space in one complete interval between tracking teeth (Q_a) to store and transport the volume of actual volume of cutting ($Q_c^{'}$). For one complete interval between tracking teeth the space available of working chain with W width is

$$Q_a = WSh_t - Q_t \qquad (10)$$

Whereh_t is the height of the cutting tooth above the working chain surface and Q_t is the volume of all the teeth theirselves of one complete interval. If the volume of all the teeth theirselvesQ_t is very small compare to the actual volume of cutting ($Q_c^{'}$).). For one complete interval between tracking teeth the space available of working chain with W width is

$$Q_a = WSh_t \qquad (11)$$

The space available for cutting should be equal to, or greater than, the volume of loose cuttings produced in a working sweep, and therefore a design condition is

$$Q_a \geq Q_c^{'} \qquad (12)$$

i.e.

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$$WSh_t \geq K_b WSd \frac{U}{u_t}\left[1 - \frac{R}{d}\sin\phi(1 + \cos\phi - \sin\phi)\right]$$

$$\frac{h_t}{d} \geq K_b \frac{U}{u_t}\left[1 - \frac{R}{d}\sin\phi(1 + \cos\phi - \sin\phi)\right] \tag{13}$$

or, with a long bar and small nose radius,

$$\frac{h_t}{d} \geq K_b \frac{U}{u_t} \tag{14}$$

ACCELERATION AND TRANSPORT OF CUTTINGS

The minimum power needed for acceleration of cuttings N_T is given by the rate of supply of kinetic energy:

$$N_T = \frac{\rho.Q.u^2}{2}, \tag{15}$$

where ρ is in-place density of the soil, u is the absolute tool speed. and Q the volumetric production rate:

$$Q = U.W.d, \tag{16}$$

Where U is traverse speed, W is width of working chain. When U/u_t is small, as is usually the case, absolute tool speed u $\approx$ tangential tool speed u_t. The corresponding force F_T is

$$F_T = \frac{\rho.Q.u_t}{2}, \tag{17}$$

CHECK DESIGN CONDITION FOR ADEQUATE CONVEYING OF TRANSFORMING RUSSIAN DIGGING MACHINE PZM-2

The original Russian digging machine PZM-2 is designed for digging trenches in mountain area where the soil conditions are dry and britle. In order to transform PZM-2 so that it can dig trenches in the red river delta with sticky clay or gumbo-type conditions, we replace the original bullet bits by flat cutting blades, and below is the checking condition for adequate conveying.

The transforming digging machine PZM-2 is intended for digging of trenche with wide W = 0,65 m; maximum depth d = 1,2 m. The cutting teeth are arranged with 5 cutting track and on every chain's link, the length of one link 0,125 m. the height of the cutting tooth above the working chain surfaceh$_t$ = 65 mm. The machine can make a single-pass traverse of a3 m/min, chain speed and tooth speeds are the same with 2 value 240 m/min and 300 m/min.

Traverse speed U = 3 m/min; tangential tooth speed: u_t = 150 m/min and 240 m/min; with 5 cutting track, thelongitunal tooth spacing S = 0,125.5= 0,625 m, taking $\Phi = 70^0$.

- Thus with u_t = 150 m/min, the theoretical cutting depth h is:

  $h = \frac{3}{150} 0,625 sin70$= 0,01174 = 11,74 mm
- Thus with u_t = 240 m/min,the theoretical cutting depth h is:

  $h = \frac{3}{240} 0,625 sin70$ = 0.007341 m = 7,341 mm;
- The required design condition for adequate conveying is

$$\frac{h_t}{d} \geq K_b \frac{U}{u_t}$$

$\frac{h_t}{d}$ = 65/1200 = 0,05417

$K_b \frac{U}{u_t}$ = 2,6.3/150 = 0,052 (with u_t = 150 m/min)

$K_b \frac{U}{u_t}$ = 2,6.3/240 = 0,0325 (with u_t = 240 m/min)

Bucking factor for clay K_b= 1.8 - 2.6

Thus: transforming digging machine PZM-2 is theoretically capable of clearing its cutting systematically with U =3m/min and u_t = 240 m/min and it isn't theoretically capable of clearing its cutting systematically with U =3m/min and u_t = 150 m/min.

CONCLUSIONS

This study has shown us that the chipping depth of a chain trenching machine is related to the tangential tooth speed u_t, the traverse speed U, the spacing between teeth S and the angle of the cutting assembly Φ.

If working length of the tooth is known, the maximum of traverse speed U can be determined by formul (3) and a consideration can be taken when design or transforming a chain trenching machine.

Inequality (16) is actually oversimplified,it suffices to demonstrate the general design considerations to either adequate available space for conveying the cutting soil or not.

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CONTACTS

Doan Dinh Diep, Department of Construction machines, Hanoi Architectural University, Vietnam, Tel.: +84 90 413 7638, e-mail doandiep2364@gmail.com

Review of the Main Stages of Developing Hydru Car for Participation in Shell Eco Marathon

Ivan Beloev

Abstract: *The paper presents the conceptual idea of University of Ruse team for creating a prototype of an urban car driven by hydrogen fuel cell energy. Shown are the steps and development stages. A special accent was put on the design of the car. Presented is the connection between the different car systems and elements of the two car prototypes R1 and R2 created by now for the participation in the international competition Shell Eco Marathon.*

Keywords: *transport, urban concept vehicle, electric vehicle, hydrogen, design*

INTRODUCTION

The creation of the Hydru car goes through different stages that aim at building a real model based on the initial ideas outlined in the sketches. The complexity of the entire procedure was how to select the most appropriate materials and technologies in order to implement the project in time.

The purpose of this article is to briefly illustrate the steps the car development has gone through. They highlight the main problems the team face until succeeding to achieve its original design.

The biggest achievement comes from the fact that despite the short deadlines, the team managed to create two versions of the car. With the first R-01, the team participated in the Shell celebrations in Sofia, and three months later, the R-02 version was created. It is lighter in terms of weight, has paid more attention to details, participated in the Shell eco marathon in Istanbul and won the prize for best design.

PROJECT TIMELINE

After the initial presentation of the vehicle concept designs, few of them were selected for further development. Some of the models were also rendered and sketched using specialized software products (Fig. 1, Fig. 2).

With a clear concept in mind, the HydRU race team members proceeded to the stage of prototyping the first version of the vehicle. As the shape of the car is extremely complex was chosen a modelling method that uses projection of the vertical sections of the vehicle on Expanded polystyrene hard foam (XPS). A total of 52 vertical sections were made and after their projection on the XPS, they were cut, glued together and smoothen (Fig. 3).

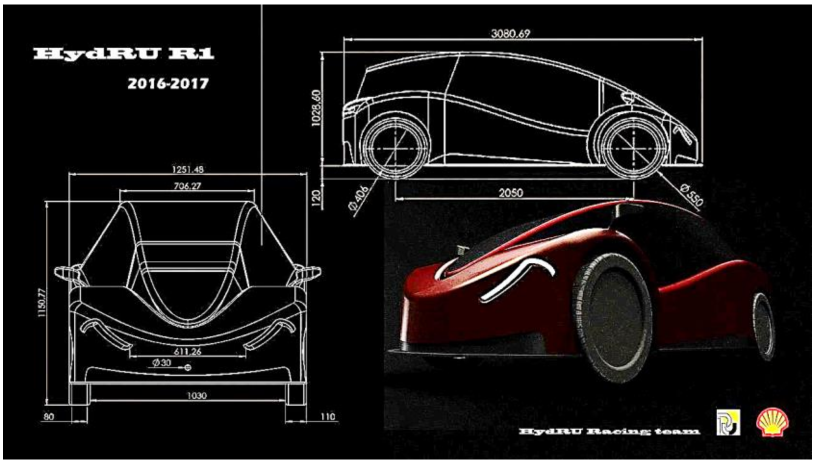

Fig. 1 Based on the 3D computer designed models, a hybrid design was chosen, so that the advantages of all concepts are kept, but their disadvantages are reduced as much as possible

Fig. 2 Rendered models of car

Fig. 3 Different stages of the modelling using the vertical sections of the car made from XPS

With the model ready we have proceeded with the softening of the vehicle surfaces and application of isolation materials, so that resin can be applied without damaging the XPS model (Fig. 4).

Fig. 4 The team after the sanding of the vehicle model and the car after the isolation material was applied

After the preparation of the vehicle for the next stage, the car model was covered by layers of resin and fiber cloth (Fig. 5).

Fig. 5 Part of the team while applying layers of resin and fibre cloth to the vehicle model. Due to the specifics of the process and the requirement for the drying of the resin, we had to work even till very late in the night

When all of the layers of resin and fibre cloth were applied, the imperfections were resolved using fine polyester filler and sanding of all surfaces. The XPS model was then removed and the final rough and unpainted body of the vehicle was completed. The next step of the process involved the generation of different color patterns for the car painting. Several different versions were proposed (Fig. 6) and all team members had to vote for their best choice. The final version of the first prototype was selected to be painted in solid white color (Fig.7). This model was named R01 and was presented to the mass media and to the general public during an event called “10 years of Bulgarian participation in Shell eco marathon”.

1080-M22 Matte Deep Black/Satin Rising Sun Gold

1080-M22 Matte Deep Black/Satin Urban Jungle Silver Green

Gold Orange Pearlescent/1080-M10 Matte White
1080-M22 Matte Deep Black

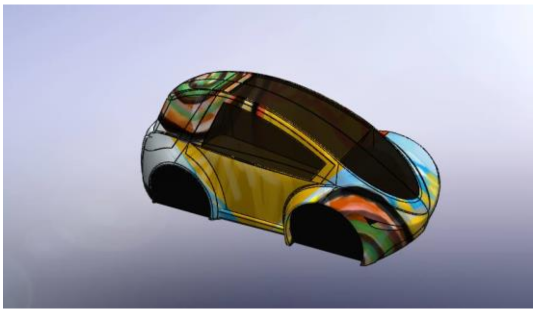

Fig. 6 Some of the color combinations, which were proposed for the vehicle paining

Fig. 7 The final version of the first version of the vehicle (Model R01).
The whole car was painted in white

After our participation in the event, was taken the decision to modify the initial

prototype of the vehicle in order to reduce its weight and to make some of the components detachable. As a result almost the entire prototype was cut into pieces, which were thinned out and used to make moulds and cast the new components of the vehicle body (Fig. 8).

Fig. 8 The initial prototype of the vehicle was cut and the parts were used to make moulds and cast the new body components

The final vehicle frame and all of the body components were painted according to the choice of the team members (Fig. 9).

Fig. 9 Moments from the painting of the vehicle frame and body components

CONCLUSIONS

The entire vehicle design and construction was a long, but fruitful process for the entire team. For the 12 months from the first kick-off meeting till the Shell Eco Marathon Challenge in Turkey we have learnt many new things and we have managed to improve significantly our skills. We have formed new friendships and by presenting the car we have attracted attention on a regional and national level. In a year we have managed to make not 1, but two versions of our car. Model R01 was a vital part of the design process, but Model R02 has turned into a real marble. Its convertible design and the different configuration present us with a modern looking and flexible single seat urban vehicle.

Fig. 10 The team with Model R02 during the presentation of the car in front of the main university building in Ruse, Bulgaria

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CONTACTS

Ivan Beloev, Department of Transport, Faculty of Transport, University of Ruse, 8, Studentska str., 7017 Ruse, Bulgaria, e-mail: ibeloev@uni-ruse.bg

Soil Microbial Activity under the Influence of Advanced Technologies for Minimum and Unconventional Tillage

Gergana Kuncheva

Abstract: *Cultivation of crops on sloping agricultural lands can cause occurring of water erosion and the related to it degradation process - loss of organic matter. The negative consequences of their development are deterioration of the physical, agrochemical and biological properties of the soil. To prevent degradation processes, a number of agro-technical measures, methods and technologies are applied. The activity and the composition of soil microflora are sensitive indicators of soil processes. The present study explores the impact of conventional and soil-protecting technologies on soil microbial activity.*

Keywords*: water erosion, minimum tillage, vertical mulching, surface mulching, soil microbial activity.*

INTRODUCTION

Water erosion causes significant changes in the physical and chemical properties of the soil, resulting in deterioration of biological ones. Research on lands with natural vegetation, soils of varying degrees of degradation as a result of water erosion, as well as eroded soil under the application of restoration measures, have shown that the microbiological activity of eroded soils is 8-10 times lower compared to lands with natural vegetation (Nunes et al., 2012). In soils under restoration, carbon and nitrogen in microbial biomass were increased 5 times and twice respectively compared to highly degraded soils (Nunes et al., 2012)

Except in biogeochemical cycles, plant nutrition, soil microflora has an important role in the formation of soil structure. Aggregation of soil particles is important for improving soil aeration, infiltration and erosion sustainability (A. Bot, 2005, Tisdall and Oades, 1982).

According to Pascual et al. (1999) soil chemical and physical parameters such as organic matter, nutrient concentration, flow measurement and soil structure are used as indicators of soil quality, taking into recording the degree of degradation. But these parameters change slowly and long periods of time are needed to record significant differences. Biological and biochemical indicators, on the other hand, are more sensitive to small changes occurring in the soil, thus providing rapid information on changes in soil. Microbiological activity changes rapidly due to rapid propagation, short life cycle, and sensitivity to changes in the environment. This leads to rapid changes in biological and biochemical soil indicators resulting from different processes (Pascual et al., 1999).

In all countries of the world and in Bulgaria, where exists the problem with water erosion and with the loss of organic matter in the soil, a systematic control is under way to limit these degradation processes, mainly using agro-technical erosion control measures, methods and technologies due to their advantages – their easy applying, rapid soil protection effect and their relatively low expensies. To limit the degradation processes water erosion and reduction of soil organic matter in cultivation of crops on slope terrains, advanced technologies for minimum and unconventional (surface and vertical mulch) soil tillage have been developed and applied. They have been developed by the Institute of Soil Science, Agrotechnology and Plant Protection "Nikola Pushkarov" - Sofia together with University of Ruse "Angel Kanchev".

The aim of the present work is to identify the changes occurring in some physical and chemical properties of the soil as well as its microbial activity under the application of conventional and advanced soil protection technologies for minimum and unconventional tillage of the soil for cultivation of maize on sloping agricultural lands.

MATERIALS AND METHODS

The field experiments were carried out in the period 2012-2017, in the field of the Experimental Station for Erosion Control - Ruse, to the ISSAPP "N. Pushkarov "- Sofia, on the territory of the village of Trastenik, Rousse, under non-irrigated conditions, on average eroded carbonate chernozem, with a slope of 50 (8.7%), in two stages. The experiments of 2012 - 2014 y. have been carried out using mulch material ready compost for vertical and surface mulching and those in the period 2015-2017y. were carried out with manure.

Experimental variants are:

1. maize plots, grown by using conventional technology, applied along the slope - control;
2. maize plots, grown by using conventional technology applied across the slope;
3. maize plots, grown by using erosion control technology, including surface mulching with ready compost or manure, all operations applied across the slope;
4. maize plots, grown by erosion control technology, including soil tillage without reversing the layer - loosening and soil protection operation vertical mulching with ready compost or manure, making slits with ducts, along with sowing and digging and furrowing along the hilling (advanced technology for minimum unconventional soil tillage) applied across the slope.

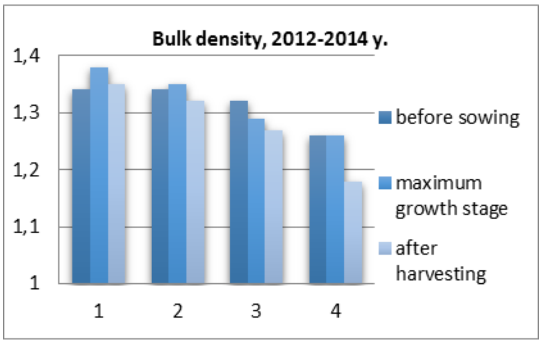
Annualy soil indicators (bulk density, total porosity, soil humidity in the 0-150 cm layer) were determined, and were carried out agrochemical and erosion studies, as well as microbiological analyzes in three phases of the crop development.

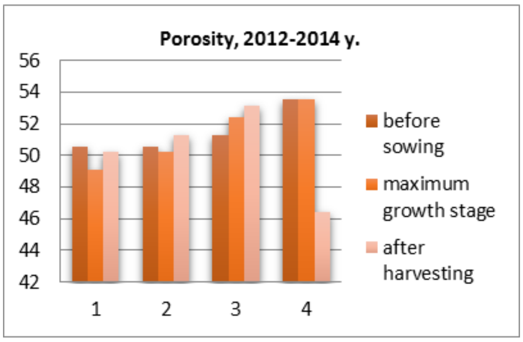
Isolated and quantified saprophytic soil microflora (total number and spore-forming bacteria) by the Koch method on peptone meat agar - for bacteria, starch ammonia agar - for actinomycetes, medium of Eshbie for nitrogen fixing bacteria, medium of Hutchinson to determine the amount of cellulose-decomposers.

RESULTS AND DISCUSSION

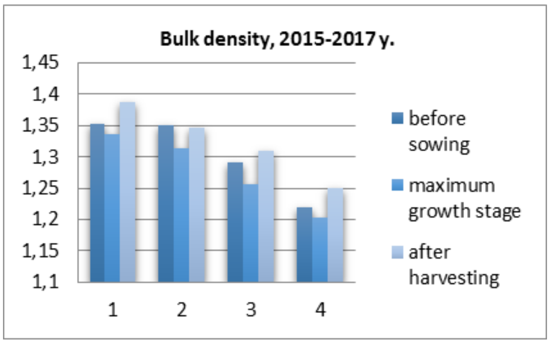
The influence of applied technologies on some physical indicators of the soil is shown in Fig. 1. From the data submitted to it, it can be seen that the use of the advanced soil protection technology, including the erosion measures, vertical mulching, making slits with ducts, along with sowing and digging and furrowing along the hilling, contributes to the reduction of the bulk density and increase of its general porosity. This trend was observed both in the first survey period of 2012-2014 and in the second 2015-2017, with the use of various mulching materials.

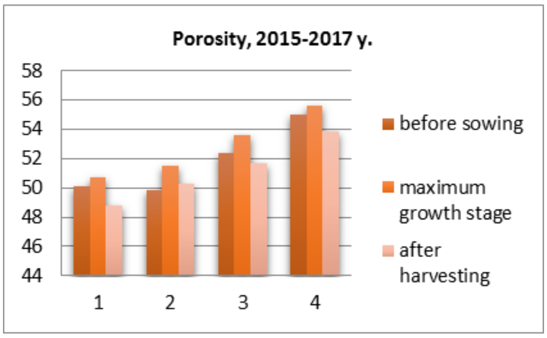
Improving these soil indicators allows to increasing the water permeability and moisture content of the soil, positively influencing both the development of the cultivated crop and creating favorable conditions for the development of the soil microflora (tabl.1). The moisture content of 2, 3 and 4 (mulch with compost) variants is 0.09%, 0.97% and 1.44%, respectively higher than in control, for the initial phase of the study (pre-sowing). In the next two phases (maximum growth and harvest), the humidity in variant 2 was 0.36% and 0.32% higher than in control - variant 1, in variant 3 with 1.14% and 0.90%, at 4 - with 3.61% and 1.80%. When applying manure as a mulching material, a similar trend is observed. The moisture in variant 4 was 2.42%, 1.90% and 2.57% higher over the three observed phases compared to the control variant.





ANOVA: Bulk density 2012-2014; p= 0.000558; HSD[0.05]=0.08; HSD[0.01]=0.1; Porosity: P=0.0001 HSD[0.05]=2.49; HSD[0.01]=3.13;





ANOVA: bulk density: p= 0.000700; HSD[.05]=0.07; HSD[.01]=0.09; 1 vs 2 nonsignificant; 1 vs 3 P<.05; 1 vs 4 P<.01; 2 vs 3 nonsignificant; 2 vs 4 P<.01; 3 vs 4 nonsignificant; total porosity p=0.000716; HSD[.05]=2.42; HSD[.01]=3.31

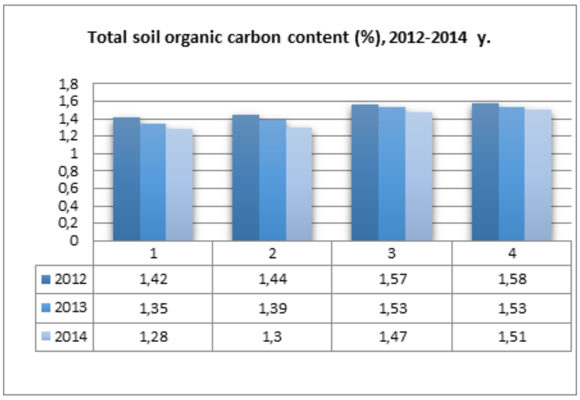
Fig. 1 Average bulk density and total porosity experience wheat for 2013-2015 observed in three phases

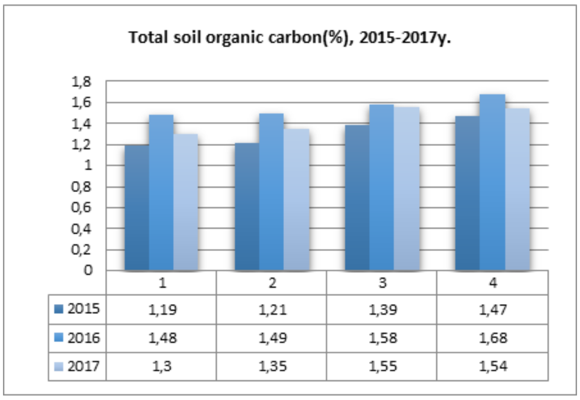
Table 1 Soil moisture 0-150cm, 2012-2014y.and 2015-2017y.

Year	Phase	1	2	3	4
2012 y.	*Sowing*	19.99	20.21	20.60	21.37
	Maximum growth stage	7.71	8.25	8.98	11.53
	After harvesting	8.72	9.05	9.06	9.39
2013 y.	*Sowing*	15.60	15.60	15.90	16.41
	Maximum growth stage	13.85	14.30	15.06	15.09
	After harvesting	9.32	9.86	10.62	11.11
2015y.	*Sowing*	17.90	17,95	19,90	20.03
	Maximum growth stage	14.17	14.25	15.15	19.95
	After harvesting	10.45	10.56	11.52	13,40
2012-2015 y.	*Sowing*	17,83	17.92	18,80	19,27
	Maximum growth stage	11,91	12,27	13,06	15,52
	After harvesting	9,50	9,82	10,40	11,30
2015 y.	*Sowing*	19.63	19.63	21.01	21.35
	Maximum growth stage	7.04	8.13	9.33	10.25
	After harvesting	22.60	23.45	24.10	25.85
2016 y.	*Sowing*	16.74	16.74	19.28	19.81
	Maximum growth stage	9.87	10.03	10.41	11.37
	After harvesting	9.18	10.44	10.68	12.05
2017y.	*Sowing*	17.71	17.71	18.36	20.20
	Maximum growth stage	12.85	13.30	13.44	13.85
	After harvesting	10.98	11.34	11.44	12.54
2015-2017 y.	*Sowing*	18,03	18,03	19,55	20,45
	Maximum growth stage	9,92	10,49	11,06	11,82
	After harvesting	14,25	15,08	15,41	16,81

The combination of minimum tillage with the importation of compost or manure as a mulching material into the improved erosion control tillage leads to preservation and

improvement of the humus content of the soil as shown in Fig. 2. The importation of organic matter with surface mulching in the third variant also results in the storage and increase of the soil organic matter. All these effects have a positive impact on both the growth of the cultivated crop and the soil microflora, which has a major impact on soil and humus formation.





ANOVA: P<0.0001HSD[0.05]=0.05; HSD[0.01]=0.06 ;   ANOVA p=<.0001; HSD[.05]=0.15; HSD[.01]=0.19

Fig. 2 Total soil organic carbon content (%)

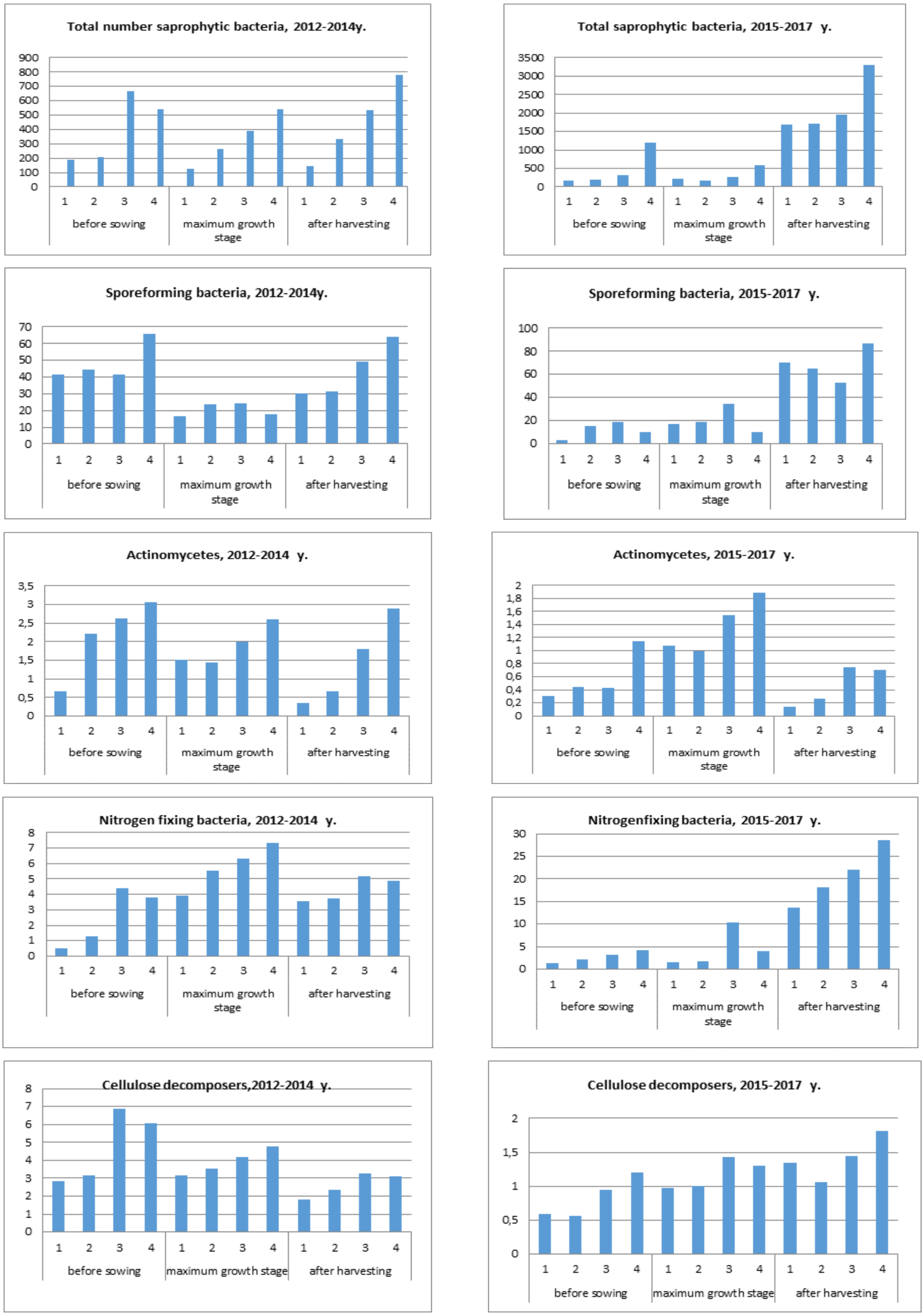
As a result of the improvement of the air and water regimes of the soil as well as the imported organic matter with a high content of nutrients, application of the applied soil protection technologies for minimum and unconventional tillage of the soil for growing maize on slope lands helps to enhance its microbiological activity (Figure 3).

Highest microbiological activity was observed in the variant 4 - using minimum tillage with vertical mulching, both with compost and manure (Figure 3). In this variant, the amount of heterotrophic bacteria was increased by an average of 4.09 times in the experiment with application of compost and 3.50 times by manure application compared to the control variants cultivated by conventional technology, applied along the slope. Higher porosity, soil humidity and lower bulk density, in variant 4, significantly influence the development of soil microflora.

The reported amount of actinomycetes in variant 4 is on average 3.40 times higher when mulching with compost and 2.47 times when manure is applied, compared to conventionally tilled areas.

Surface mulching with compost also has an increase in microbiological activity, with the total number of saprophytic bacteria being 3.50 and 1.23 times higher than the conventionally cultivated crops along the slope. The reported number of actinomycetes is 2.55 and 1.80 times higher on average for the three-year study with compost and manure respectively.

The increase of the nitrogen-fixing activity in variants 3 and 4 is also significant. In the experiment, using the advanced technology for minimal and unconventional tillage, during the two study periods it averaged 2.01 and 2.23 times higher compare to control variants. Upon application of surface mulching, the nitrogen fixation activity is increased on an average of 1.99 and 2.17 times (compost and manure as mulching material respectively) compared to the conventionally tilled plots, along the slope.



ANOVA (2012-2014 y.) Total number p=0.029954HSD[0.05]=451.65; HSD[0.01]=581.5;Spore - forming bacteria p=0.080692; Actinomycetes p=0.028579; HSD[0.05]=1.75; HSD[0.01]=2.25; Nitrogen fixing bacteria: p= 0.006229; HSD[0.05]=1.79; HSD[0.01]=2.30; Cellulose decomposers p=0.043562; HSD[0.05]=2.11; HSD[0.01]=2.63
ANOVA (2015-2017 y.) Total number p=0.621495; Cellulose decomposers p= 0.1789

Fig. 3 Soil microbiological activity in CFU (colony forming units)* 106/g dry sol, average for three years periods 2012-2014 y. and 2015-2017 y.

Cellulose degradation activity is also enhanced in variants 4 and 3 of both experiments. In variant 4, the increase by using compost, as mulching material, is 2.82 times, and when manure is applied - 3.18 times versus variant 1. With surface mulching this increase is 1.53 and 2.19 times in compared to the control conventionally grown along the slope.

CONCLUSION:

− Advanced soil protection technology that includes soil tillage without reversing the layer - loosening and soil protection operation vertical mulching with compost or manure, making slits with ducts, along with sowing and digging and furrowing along the hilling (advanced technology for minimum unconventional soil tillage) applied across the slope has a proven erosion control effect.

− Application of erosion control operations such as surface mulching and minimum tillage with vertical mulching significantly improve the bulk density, total porosity and water retention capacity of the soil.

− The application of these two soil-protection technologies for maize grown on sloping terrains leads to the preservation of the soil organic matter.

− All these positive effects on the soil, as a result of the application of advanced technology for minimum and unconventional tillage, lead to increased microbial activity, which has a major role in the soil formation, humus formation, the aggregate stability of the soil particles, the release of nutrients.

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CONTACTS

Gergana Kuncheva, Scentific section "Erosion of soil", Institute of Soil Science, Agrotechnologies and Plant Protection "Nikola Pushkarov" – Sofia,
e-mail: g1nikolova@abv.bg.

Touchless Control of a Stationary Manipulator

Vlastimil Slany, Jan Marecek, Eva Krcalova,
Ivan Beloev, Vladimir Krocko, Miroslav Pristavka

Abstract: *This article describes the creation of a non-contact control of a stationary manipulator. The Kinect device from Microsoft is used to capture and evaluate the video image. C ++ and C # were selected as the main programming languages. The C # programming language was used to create a Graphical User Interface (GUI). Microsoft offers direct support for the developers in the SDK (Software Development Kit). As a stationary manipulator, was selected the KATANA HD6M180 from the Swiss company Neuronics HD. This is a manipulator that can be controlled using the Katana Native Interface (KNI) library. This is a C ++ written library. It is a manipulator with 5 degrees of freedom. In this article is also described a GUI design, including a proposal for the individual control movements. Part of this article is also the design and creation of a control library that takes care of the communication between the created control software and the stationary manipulator. This library is written in C ++ programming language.*

Keywords*: Kinect, KatanaHD300, KNI , automatization, touchless control*

INTRODUCTION

The aim was to design and implement the Katana stationary manipulator trajectory (HD300s) through body movements. The Kinect device from Microsoft is used to capture motion. It has also been necessary to explore and select the appropriate programming language in terms of compatibility and support for individual devices. Based on the chosen programming language, a suitable SDK library (Software Development Kit) was chosen to enable us to communicate with Kinect device. It was also necessary to devise and choose a suitable control system, where we assign individual movements of human body to controlling each of the engines. An integral part of this work is also the Graphic User Interface (GUI) for communication with the user with respect to the selected programming language. Here, it is necessary to convert these data into a format that is accepted by the stationary manipulator Katana [1].

MATERIAL AND METHODS

Used hardware Kinect

The Microsoft Kinect sensor was considered a breakthrough in user interaction and controlled device, whether it is a personal PC or an Xbox 360/ Xbox One game console for which it was originally developed, under the project name Project Natal.

It is a motion control system that records user movement and translates it into control commands. So the user does not need any driver or controlling device and everything is done through the NUI (Natural User Interface). At the time of the release of this device, Microsoft was the first to come with a combination of 3D capture, facial and voice recognition. And this combination of hardware and software has enabled control without any peripherals (such as buttons or controls). All you need to do is stand in front of the Kinect device and use your body and natural moves or voice or gestures [2]

The accuracy decreases with the increasing distance of the object from our sensor. For better illustration, Figure 1 shows maximum and minimum possible distances while maintaining accuracy. It is also necessary to take into account whether the sensor works in the mode of the standard or decreased distance. The mode of the decreased distance was added at newer models, which were designed primarily for PC. For this reason, Kinect can be used in many industries [3].

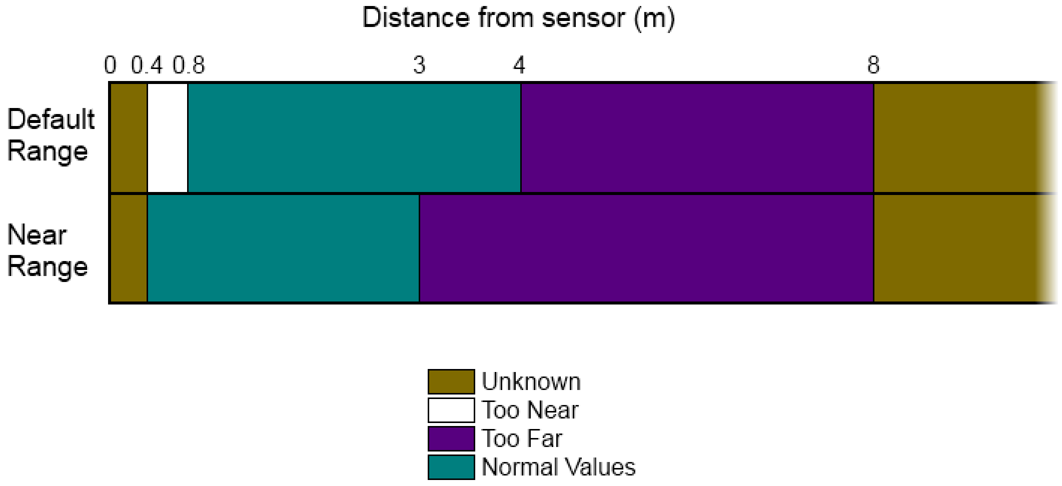


Fig. 1 Kinect sensor distance – taken from www.msdn.microsoft.com

Katana HD300s

It is a stationary manipulator based on the model series HD300 of the Swiss company Neuronics AG. Due to its size and carrying capacity (500 g), it is primarily intended to be handled with small and light objects in practice. One of the typical tasks that this manipulator can perform on production lines is "pick and place". There is also the possibility to extend the camera-scrambling manipulator and to subsequently evaluate the input. This is especially useful on lines where defective products are being checked or automated stacking of items [4].

The following coordinate systems are defined in the Katana 6M180 manipulator.

- K_w - World coordinate system
- K_{tool} - Coordinate system of the tool
- K_B - Base coordinate system – pedestal

Figure 2 shows all these systems and their mutual relations.

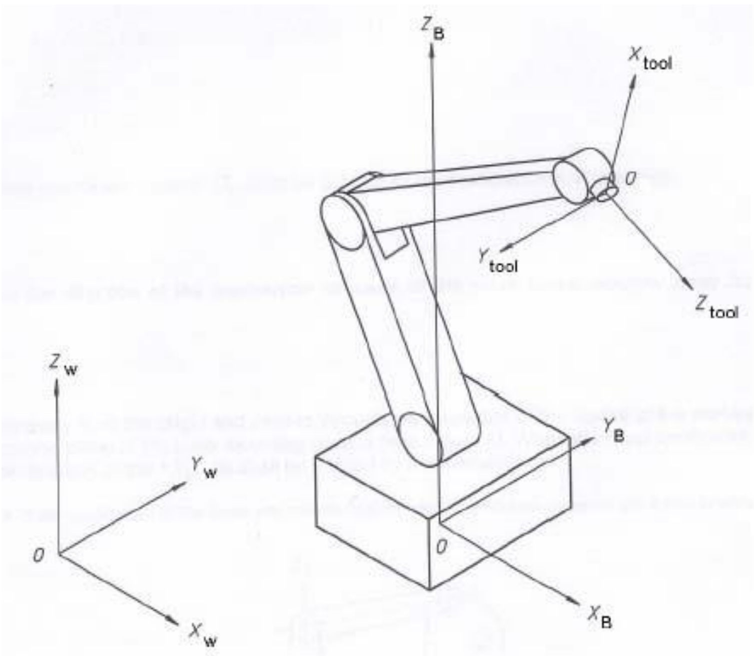


Fig. 2 All coordinate systems – taken from Neuronics AG

On the figure 3 we can see the Katana 6M180 with the designation of individual motors.

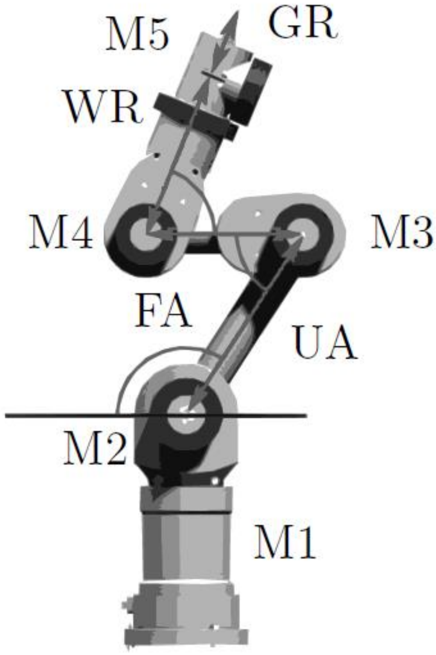


Fig. 3 Katana 6M180 – taken from Neuronics AG

KNI Library

It is a software library that is designed for the development of control software for Katana robots. This library is created in the C ++ programming language. It is therefore divided into classes and structures.

This library provides easy methods for controlling a stationary manipulator Katana without starting basic protocols. As can be seen in Figure 4, it consists of the Communicatrion Device Layer (CDL), the Communication Protocol Layer (CPL), and the Katana Robot Model Layer. (Neuronics AG, 2006c)

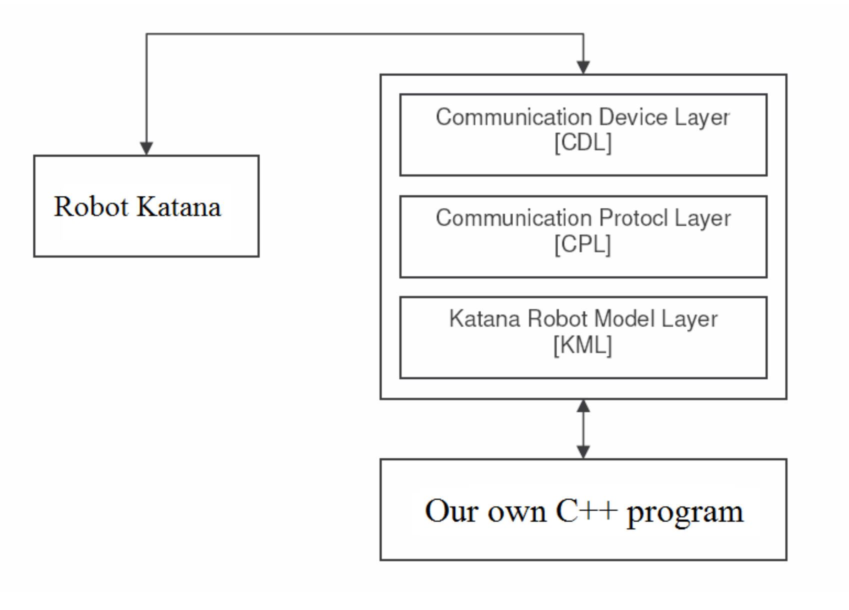
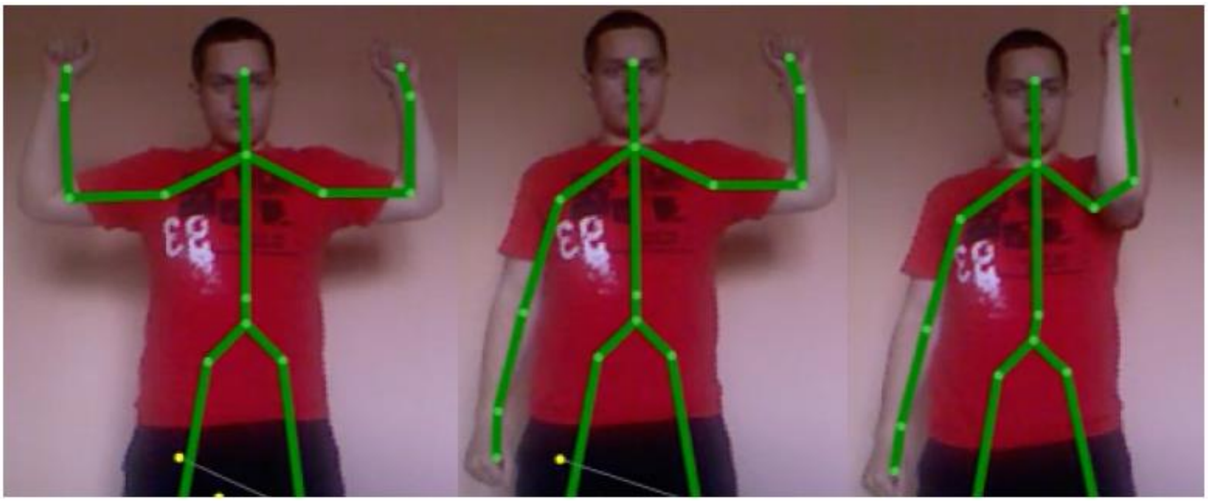


Fig. 4 Structure of the KNI library – taken and edited from Neuronics AG

RESULTS AND DISCUSSION

This work is based on relative control. The concept of relative control is based on the comparison of two skeleton images. It is therefore necessary to save the image of the skeleton, wait for the new skeleton image, to make a comparison between these images based on the obtained and calculated data. This solution is simpler than absolute control in our case, but it also has its own pitfalls. The first is the need to calibrate our user. Each person has different body proportions, so the calculated values can vary considerably among individual people. It is also necessary to carefully treat the movement limits so that these limits cannot be exceeded. Calibration of the user is performed using the start gesture. The other option is to use the inverse kinematics inverse role to calculate the position of the manipulator with five degrees of freedom based on scanned values [5].

This means that until the user has made a predetermined start gesture from which it is possible to read the necessary data for controlling the stationary manipulator, he will not be allowed to manipulate with manipulator. The main advantage of this approach is to temporarily interrupt scanning, positioning the hand to the desired starting position, and then continue driving manipulator. Therefore, unlike the absolute control, it is not necessary to navigate the user to the previous end position, but the user can determine his start position himself. Thus, the main disadvantage of the previous steering system is that we need to change the position of one engine without affecting the other engine. Here, we just can stop the scanning, put our hand to a different starting position from which it will be possible continue to control the manipulator. We have 5 engines, which can be controlled. For example, on Figure 5, we can see minimal and maximal position for controlling engine 1 [6].



Start gesture Minimal position Maximal position

Fig. 5 The pattern of start gesture, minimal and maximal position for engine 1

Convert output scanned data from Kinect device to stationary input data of the manipulator depends largely on the option of reading data. In this work is described option, which is called (in this paper) as relative trajectory planning. It is necessary to compare the two captured skeleton records. For this purpose, the image of the skeleton according to which the last evaluation was performed is stored in memory. After that, a new image is taken, which is compared to the last recorded image.

Based on this comparison, it is possible to determine which joint has the largest change in its position compared to the last image. It was also necessary to choose the appropriate interval in which scanning and skeleton comparison will be performed. After testing the individual positions, the 200 ms interval was selected. The choice of this interval was largely influenced by the technical parameters of the stationary manipulator, when it is not possible to send the control information in the interval less than 200 ms. Commands that are sent in less than 200 ms are ignored and will not be executed. As mentioned above, the Katana stationary manipulator has 5 engines that can be controlled. Each of these engines has a different range in which we can move. In table 1 we can see the ranges of encoders of individual motors.

The Kinect returns the numerical distance of the knuckles from the point "0" as the output, which in our case is the Kinect device position itself. This distance is reported in meters with an accuracy of 1 cm. The output is a decimal number with accuracy of 2 decimal places. In order to be able to convert these input data to the input data of the stationary manipulator, motions have been determined to uniquely identify the engine to be controlled.

Then a stationary step of 1000 encoder units is added to the particular encoder in the evaluated direction. If the encoder value is equal to the maximum or minimum amount, and the stationary manipulator should exceed this value, the encoder value is set to either maximum or minimum, and cannot therefore exceed this limit. However, if any program bug could occur to circumvent this security algorithm, this situation is treated in library (KNI) of the stationary manipulator Katana. There should therefore be no damage to the stationary manipulator due to exceeding the limits of the individual encoders.

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CONTACTS

Vlastimil Slaný, Mendel University in Brno, Department of Agricultural, Food and Environmental Engineering, e-mail: xslany@mendelu.cz

Jan Mareček, Mendel University in Brno, Department of Agricultural, Food and Environmental Engineering, e-mail: jan.marecek@mendelu.cz

Eva Krčálová, Mendel University in Brno, Department of Agricultural, Food and Environmental Engineering, e-mail: xkrcalo1@node.mendelu.cz

Ivan Beloev, Department of Transport, Faculty of Transport, University of Ruse, 8, Studentska str., 7017 Ruse, Bulgaria, e-mail: ibeloev@uni-ruse.bg

Vladimir Krocko Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak republic, e-mail: vladimir.krocko@uniag.sk

Miroslav Prístavka, Department of Quality and Engineering technologies, Faculty of Engineering, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, miroslav.pristavka@uniag.sk

Determination of the Maximum Allowable Slipping of the Wheel Tractors

Vladimir Nadykto, Vladimir Kurchev, Hristo Beloev, Georgi Mitev

Abstract: *One of the most important parameters that characterize traction-coupling properties of a wheeled tractor is its slippage when operating in a particular machine-tractor unit. The article gives a formula that allows to determine practically the reliable value of this parameter. The difference between this formula is that it does not take into account the loss of speed of the tractor due to the reduction in engine speed, which occurs under the influence of traction load. Overcoming this load, the tangential traction force of the tractor should not exceed the maximum possible adhesion to the soil Pkmax. In the paper, the condition is used that the ratio of this force to the sum of the vertical projections of the stubborn surfaces of the tractor's tractors should not exceed a given pressure on the soil [Q]. On the basis of this, an equation is derived that allows to determine the maximum permissible level of slipping of the wheel tractor δmax. In this equation, the value of δmax basically depends on such characteristics of the soil as the coefficient of volume collapse and the coefficient of rolling resistance. The ratio of permissible pressure on the soil [Q] to the rolling radius of the tractor wheels can be regarded as practically constant. Calculations showed that for soils with an average collision rate of about 4000 kN·m-3, the average rolling resistance coefficient is – 0.16, and the ratio of permissible soil pressure to the rolling radius of the wheel – is at 222 kPa/m, the maximum permissible value slippage of the tractor wheels δmax should not exceed 15%.*

Keywords*: slipping, wheel tractor, coefficient of rolling resistance, bulk deformation of soil.*

INTRODUCTION

Since the wheeled tractor is a traction machine, slipping of its wheels is not an exception, but the norm. Theoretically, this process occurs at the moment when the wheel starts to move under the influence of the torque applied to it, which creates the tangential force of the thrust (P_k).

Studies have established (Guskov V.V. et al., 1988) that the tractor in the traction machine-tractor aggregate achieves the highest traction-coupling properties when the wheels (δ) have slippage at 20-22%. But because of the intensive slippage of the tires and the soils of the wheels with respect to the bearing surface, there is a shift, crushing and considerable abrasion of the soil. As a result, it loses its structure and fertility (Battiato, A. et al., 2011, Noréus, O. & Trigell, A., 2008), the restoration of which is a very long, laborious and expensive process.

Consequently, the maximum value of skidding of the tractor wheels (δmax) should be such that the destructive effect on the soil is minimal. At first glance this problem can be solved by appropriate ballasting of the tractor (Damanauskas, V., Janulevicius, A., 2015, Spagnolo, RT., Et al., 2012; Janulevicius, A., Giedra, K., 2008).

However, as practice shows, this method leads to an increase in soil compaction, which is the result of undesirable and harmful.

In another variant of the solution to this problem, it is proposed to equip the tires of the wheeled tractor with lugs in the form of spikes or blades (Abrahám R. et al., 2014). It should be noted that in off-road conditions, this complication of the construction of the tractor running system can be justified. In normal field conditions, the effectiveness of its application will depend on the value of δ_{max}. The value of this parameter can be such that the work of the tractor with skidding of the wheels no more than δ_{max} will really be provided by simply doubling the tires.

From the foregoing it follows that the main problem is to determine the value of δ_{max}. Up to now, an attempt has been made to solve this problem (Nadykto V. et al., 2015) by applying in the horizontal plane the restriction of the pressure of the wheels of tractors to soil ([Q]), which is regulated by Ukraine's standard in the vertical plane (DSTU 4521: 2006 '

Mobile agricultural machinery. Standard rates of impact on the soil by undercarriage).

As a result, it was found that to substantially reduce the destruction of the soil structure in the spring field, the maximum permissible slipping (δ_{max}) of the wheels of tractors of traction classes 5, 3 and 1.4 should be 15%, 12% and 9%, respectively. In the autumn-summer period, the values of δ_{max} can be large and accordingly make up 20%, 16% and 13%.

The difficulty lies in the fact that Nadykto V. et al. (2015) the expression for the definition of δ_{max} contains many design parameters for both the wheels and the tractor itself. And this not only significantly complicates the process of determining the value of δ_{max}, but also requires its determination for each specific traction facility.

In the real conditions of the tractor's movement, the crushing and shearing of the soil occurs under the action of the tangential force of the thrust P_k. The maximum value of its adhesion value (P_{kmax}) should be such that the pressure of the tractor wheels on the soil in the horizontal plane and their slippage does not exceed the maximum permissible values: [Q] and δ_{max}, respectively. In this case, it is quite obvious that the values of P_{kmax}, [Q] and δ_{max} are connected with certain parameters of the soil in a certain way. Determining the nature of this relationship with the subsequent determination of the maximum allowable slippage of the wheels of the tractor δ_{max} is devoted to this article.

MATERIALS AND METHODS

According to Professor E.D. Lviv, the maximum possible traction with traction of the tractor wheel (P_{kmax}) can be represented as follows:

$$P_{kmax} = \delta_{max} \cdot F_v \cdot k_o \cdot L, \qquad (1)$$

where F_v is the sum of the vertical projections of the thrust surfaces of the tractor wheels immersed in the soil, m^2; k_o – the coefficient of bulk crushing of soil, $N \cdot m^{-3}$; L – the length of the traction tractor clutch traction with soil, m.
It follows from (1) that

$$\delta_{max} = \frac{P_{kmax}}{F_v \cdot k_o \cdot L}. \qquad (2)$$

The expression for determining L is:

$$L = R_k \cdot \left(\mathrm{arctg} \frac{f_k \cdot \sqrt{1 - f_k^2}}{0.5 - f_k^2} + 2 \cdot f_k^2 \right), \qquad (3)$$

Where: R_k is the dynamic rolling radius of the wheel, m; f_k – the coefficient of rolling resistance of the tractor wheel.

As in the work of Nadykto V. et al. (2015), we assume that the ratio of the force P_{kmax} to the area F_v is a voltage that can be limited by the value of [Q] ($N \cdot m^{-2}$), which is defined by DSTU 4521: 2006 'Mobile agricultural machinery. Standard rates of impact on soil by undercarriage '. I.e:

$$P_{kmax} / F_v = [Q], \qquad (4)$$

Substituting the value of L from expression (3) into formula (2) and taking into account expression (4), we finally obtain:

$$\delta_{max} = \frac{[Q]}{k_o \cdot R_k \cdot \left(\operatorname{arctg} \frac{f_k \cdot \sqrt{1 - f_k^2}}{0.5 - f_k^2} + 2 \cdot f_k^2 \right)}. \tag{5}$$

RESULTS AND DISCUSSION

Analysis of expression (5) shows that the maximum allowable slippage of the tractor wheel depends only on one structural parameter – of the rolling radius R_k. In real conditions, the larger its value, the greater the contact area of the wheel with the supporting surface, i.e. soil. But in such a case it is possible to take a correspondingly larger value of the allowable pressure [Q]. Taking into account the growth of this parameter, with simultaneous increase in the radius of the wheel R_k in the first approximation, we can assume that the ratio of the quantities [Q] and R_k remains practically constant. i.e

$$\frac{[Q]}{R_k} \approx const. \tag{6}$$

Taking this into account, the maximum permissible value of skidding of the tractor wheels, as shown by the relationship (5), is determined by only three parameters of the soil. They are: 1) the permissible pressure [Q] ($N \cdot m^{-2}$); 2) the coefficient of volume collapse k_o ($N \cdot m^{-3}$); 3) rolling resistance coefficient f_k.

In Ukraine, as noted above, the value of [Q] is regulated by the state standard DSTU 4521: 2006 'Mobile agricultural machinery. Standard rates of impact on soil by undercarriage '. The maximum value of this parameter for the spring-summer period is 160 $kN \cdot m^{-2}$.

The most common not only in Ukraine but also in other European countries are tractors of traction classes 3 and 5. Their operating weight is approximately 8.2 and 12.0 tons respectively. Tractors of traction class 3 are equipped with tires 23,1R26, and traction class 5 – with tires 28,1R26. The rolling radius of the wheels with these tires is R_k = 0.72 m.

The value of the coefficient of volumetric soil compression k_o depends on its type, aggregate state, etc. In southern Ukraine, for example, the average value of this parameter for sod-podzolic soils is about 4000 $kN \cdot m^{-3}$.

As to the coefficient of rolling resistance f_k, its value in the field conditions is usually considered for two agrotechnical backgrounds: 1) stubble and 2) field prepared for sowing. If f_k = 0.08-0.12 for the first of them (i.e., stubble), then for the other (i.e., the field prepared for sowing) this parameter varies from 0.12 to 0.20.

At [Q] = 160 $kN \cdot m^{-2}$, R_k = 0.72 m and k_o = 4000 $kN \cdot m^{-3}$, the dependence of the maximum permissible skidding of the tractor wheel δ_{max} on the rolling resistance coefficient f_k according to the expression (5) has the form shown in Fig. 1.

\From his analysis it follows that on a more loose soil background, characterized by a larger value of the rolling resistance coefficient f_k, the maximum permissible skidding of the tractor wheels should be less. The value of this coefficient against the background of the "field prepared for sowing" changes, as indicated above, from 0.12 to 0.20. The average value of f_k is 0.16. Taking this into account, it follows from equation (5) that for soil conditions with characteristics [Q] = 160 $kN \cdot m^{-2}$, k_0 = 4000 $kN \cdot m^{-3}$ and f_k = 0.16, the maximum skid (δ_{max}) of tractors with a rolling radius their wheels at the level of R_k = 0.72 m should not exceed 15%.

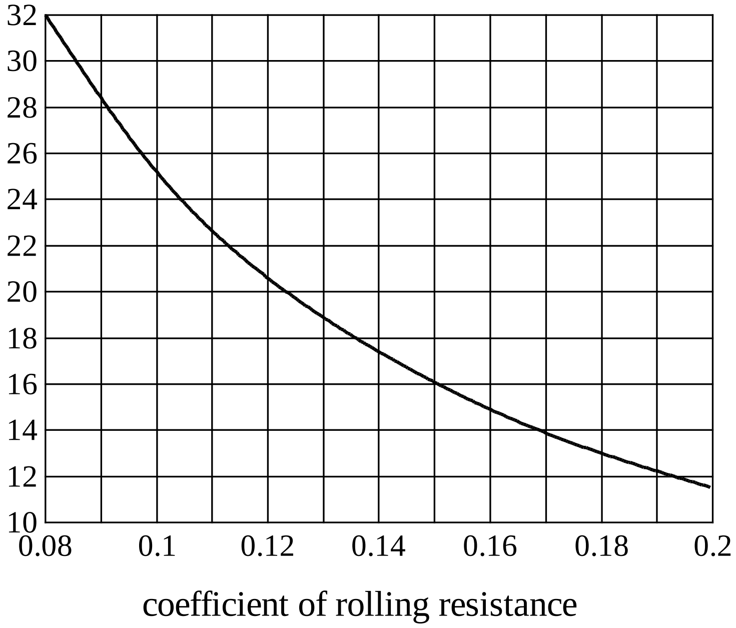

Fig. 1 Dependence maximal slipping of wheel tractor (δ_{max})
from coefficient of rolling resistance (f_k)

Moreover, the change in the parameter R_k to a greater or lesser side should not have a significant effect on the value of δ_{max}, since in this case it is possible to change (ie, increase or decrease) the value of the parameter [Q] corresponding in such a way that the condition (6).

In order to apply the maximum permissible value of slipping (δ_{max}) in practice, it is very important to be able to determine correctly in the field conditions its actual value, i.e. δ. Very often to calculate this parameter, the following formula is proposed (Lu Zhixiong, 2013; Bin, Z., Yu, Q., 1997):

$$\delta = \frac{V_x - V_p}{V_p}, \tag{7}$$

Where: V_p, V_x - the speed of the tractor with traction load and without it, respectively. However, the formula (7) is valid only in the case when the values of V_x and V_p are obtained at the same engine speed of the tractor when it moves under load (n_{ep}) and without it (n_{ep}). Those are:

$$n_{ex} = n_{ep.}, \tag{8}$$

The problem is that when the tractor moves at idle speed, that is, without traction, condition (8) can not be ensured. In this case, there will always be $n_{ep}> n_{ex}$. In the presence of traction, the actual speed of the tractor's forward speed is reduced both by skidding of its wheels and due to the mandatory reduction in engine speed. But the second circumstance is not caused by skidding, and therefore should be properly taken into account. This can be done by increasing the value of the working speed V_p by a certain amount (K_1). Theoretically, using expression (7), it looks like this:

$$\delta = \frac{V_x - V_p \cdot K_1}{V_x} = 1 - K_1 \cdot \frac{V_p}{V_x}, \tag{9}$$

If this is not done, then using formula (7) if condition (8) is not fulfilled leads to the definition of an overestimated value of δ.

The second known expression for determining slippage is the loss on the same path segment (Stajnko, D. et al., 2012; Macmillan RH, 2002) of the total number of revolutions of the tractor's driving wheels with idling (n_{wx}) and working strokes (n_{wp}):

$$\delta = \frac{n_{wp} - n_{wx}}{n_{wp}}, \qquad (10)$$

We emphasize that the quantity n_{wp} is simultaneously a function of skidding of the wheels and the reaction of the engine to the traction load. In order to exclude the second circumstance when calculating δ, the number of turns of the tractor wheels when it is moving under load must be corrected by some amount (K_2). In this case, from equation (10) we have:

$$\delta = \frac{n_{wp} \cdot K_2 - n_{wx}}{n_{wp} \cdot K_2} = 1 - \frac{n_{wx}}{n_{wp} \cdot K_2}, \qquad (11)$$

Note that the values n_{wp} and n_{wx} are functions of the path traversed by the tractor and have the dimension [turns/m]. In practice, their definition has some difficulties. In order not to burden ourselves with the necessity of dividing the field into sections of a fixed length (especially when there are a large number of them), it is more convenient to register the quantities n_{wp} and n_{wx} as functions of time n_p and n_x, having dimensions of [turns/s].

It should be borne in mind that

$$n_{wp} = n_p \cdot V_p;$$
$$n_{wx} = n_x \cdot V_x, \qquad (12)$$

Taking into account expression (12), formula (11) can be rewritten as follows:

$$\delta = 1 - \frac{n_x \cdot V_x}{n_p \cdot V_p \cdot K_2}. \qquad (13)$$

Equating the right-hand sides of formulas (9) and (13), after the transformations we obtain:

$$K_1 \cdot K_2 = \frac{n_x}{n_p} \cdot \left(\frac{V_x}{V_p}\right)^2. \qquad (14)$$

Taking into account the fact that the coefficients K_1 and K_2 are dimensionless, from the expression (14) we have:

$$K_1 = n_x / n_p;$$
$$K_2 = (V_x / V_p)^2. \qquad (15)$$

If now we substitute the expressions for K_1 and K_2 in (9) and (13) into formulas (9) and (13), we obtain the same dependence, which allows us to calculate the loss of tractor speed when it operates in the traction mode only due to skidding of the wheels i.e. without taking into account the engine speed reduction):

$$\delta = 1 - \frac{n_x \cdot V_p}{n_p \cdot V_x}. \qquad (16)$$

In the field conditions, the parameters included in the formula (16) can be easily fixed using an analog-to-digital converter and a computer. Moreover, for most agricultural tractors with a sufficient accuracy for practical accuracy, the ratio of n_x/V_x in the main working transmissions can be assumed to be approximately constant, i.e. $n_x/V_x \approx$ const.

Let's consider a practical example of an estimation of skidding of wheels of a tractor by formulas (7) and (16). Thus, when testing a tractor of traction class 3 HTZ-17021 with a five-hull plow PLN-5-35, it was found that with the traction resistance of the tiller 34.4 kN, the

real speed of the plowing unit (V_p) was 2.43 m·s^{-1}. The average wheel speed of this tractor (n_p) was equal to 0.568 s^{-1}.

As for the parameters of idling of the arable unit, then on the same gear they were: V_x = 3.00 m·s^{-1}, and n_x = 0.591 s^{-1}.

When calculating according to formula (16), the slipping of the wheels KhTZ-17021 with plow PLN-5-35 was equal to 15.7%. In the case of calculating the same parameter by formula (7), it was found that δ = 19.0%. In absolute terms, the difference (i.e., the excess) is 19.0 – 15.7 = 3.1%, and in the relative – 21.0%.

The question arises: is this a lot or a little? To get an answer, let's turn to the factory traction characteristics of the tractor HTZ-17021. When driving over the stubble, the difference between the tractive forces developed by this tractor when skidding 15.5 and 19.0% is approximately 8 kN. At the nominal tractive effort of this tractor 32 kN this is 25%. From this it follows that incorrect determination of the slippage of the tractor wheels according to formula (7) in practice can lead to its substantial underload by tractive effort. To avoid such a result, calculate slippage using formula (16).

CONCLUSIONS

One of the most important parameters that characterize traction-coupling properties of a wheeled tractor is its slippage when operating in a particular machine-tractor unit. For the practical determination of the reliable value of this parameter, the formula (16) is proposed, which does not take into account the loss of the tractor's speed due to the reduction of its engine speed due to the effect of the traction load.

In order to reduce the tractor's destructive effect on the soil, the maximum permissible slipping of its wheels should not exceed the value calculated by formula (5). For soils with an average collision rate of about 4000 kN·m^{-3}, the average rolling resistance coefficient is – 0.16, and the ratio of permissible ground pressure to the rolling radius of the wheel – is at 222 kPa/m, the maximum permissible value of slipping of the tractor wheels δ_{max} should not exceed 15%.

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CONTACTS

Vladimir Nadykto, Tavria State Agrotechnological University, 18, B. Khmelnytsky Ave, Melitopol, Zaporizhia obl., 72310, Ukraine, e-mail: volodymyr.nadykto@tsatu.edu.ua

Vladimir Kurchev, Tavria State Agrotechnological University, 18, B. Khmelnytsky Ave, Melitopol, Zaporizhia obl., 72310, Ukraine, e-mail: volodymyr.kyurchev@tsatu.edu.ua

Hristo Beloev, Department of Agricultural Machinery, Agrarian and Industrial Faculty, University of Ruse, 8, Studentska Str., 7017 Ruse, Bulgaria, e-mail: hbeloev@uni-ruse.bg

Georgi Mitev, Department of Agricultural Machinery, Agrarian and Industrial Faculty, University of Ruse, 8, Studentska Str., 7017 Ruse, Bulgaria, e-mail: gmitev@uni-ruse.bg

Guidance for Technical Inspection of Twin Tube Shock Absorbers

Zuzana Csillagova, Gabriel Polo, Plamen Kangalov,
Ivan Beloev, Lubomir Belan, Maros Korenko

Abstract: *This article is focus on instruction which describes and shows the procedure that is to be used to determine the component cleanliness of new, unused twin tube dampers in the form of a volume production test. The long-term aim of each organizations is to create and sustain a standardized level of product cleanliness which could affect its functionality. Therefore, this regular check is very important.*

Keywords: *Inspection, Disassembly, Clean, Shock Absorbers*

INTRODUCTION

Principles of damping and suspension

When the vehicle drives over a bump, suspension springs and vibration dampers are compressed. There sulting shock to the vehicle will be absorbed by the suspension. The suspension prevents a contact between the sprung mass (body and payload) and the "unsprang" mass (axle and wheels). However, the springs strive to release the stored energy by relaxing themselves again. In order to quickly settle this recoilaction of vibration between axle and body, the chassis is equipped with shock dampers.

Nowadays it is very important to create and maintain a standard level of cleanliness shock absorbers. In this process, only the inner surfaces of the shock absorber are evaluated that come in contact with the shock absorber oil.

Equipment, which we need to control:

- Four stainless steel containers
- Tweezers
- Funnel
- Filter holder
- Red nylon rod
- Measuring cylinder

Fig. 1 Types of stainless steel containers

MATERIALS AND METHODS

General principles

The cleanliness test must be performed by specially trained staff in a separate room (as per VDA 19). This person must work in protective gloves. If any gloves have been damaged or only slight contamination, it is necessary to changed them.

The test room must be equipped with an air extraction system (workplace with air extractor).

Before the start of the inspection, it is necessary to ensure the highest level of cleanliness in the working place, filtration equipment, tweezers and all containers must be thoroughly cleaned (maximum 200 μm) and dried. The mentioned equipment must be subjected to a special cleaning process (rinsing with cold cleaner) prior to the cleanliness analysis. The washing liquid used must be prefiltered using a ≤1.2 μm filter.

The cleanliness of the containers used must be ensured through blank value testing that is performed analogous to the cleanliness tests (without parts).

Implementation

Firstly, we should determine the blank value**.** The blank value must be determined immediately before the component test. The procedure is the same as described in the following rows, without the parts.

Then we can start with the control. We continue with disassembly of the twin tube damper (Fig.2).

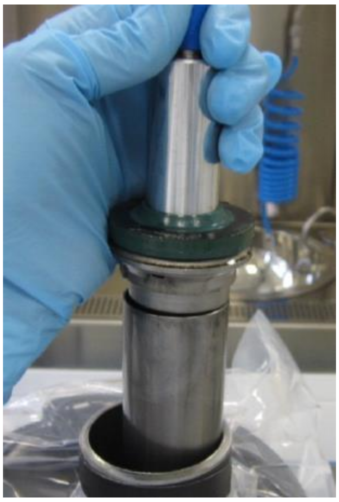

Fig. 2 Disassembly of the twin tube damper

Pull the piston rod out of the reservoir tube and place it in the stainless-steel container for components in an upright position (to prevent oil from leaking). Then loosen the guide with a light blow. Pull the guide upwards together with the seal and remove it from the piston rod. Separate guide and seal by lifting out the seal with the screwdriver (Fig.3). Discard the seal and analyze the guide only. The guide is put into the stainless-steel container together with the cylinder tube.

Fig. 3 Disassembly of components

Collect the oil from the inner and outer tube in the stainless-steel container for oil (Fig.4) and pull the piston rod out of the cylinder tube (Fig.5).


Fig. 4 The stainless-steel container for oil

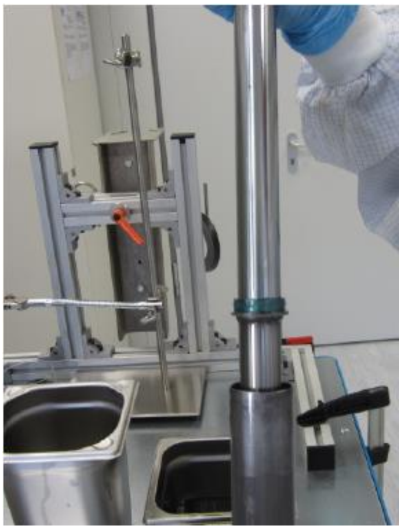

Fig. 5 Disassembly of the piston rod out of the cylinder tube

Then in the cylinder tube remaining oil is poured to the collected oil volume. Then measure the total quantity of the contained oil using a cylinder measuring cup (Fig.6) and pour it back into the stainless-steel container.

Fig. 6 Measuring cup

Next follows the extraction of each the testing components with cold cleaner into the stainless-steel container (Fig.7).

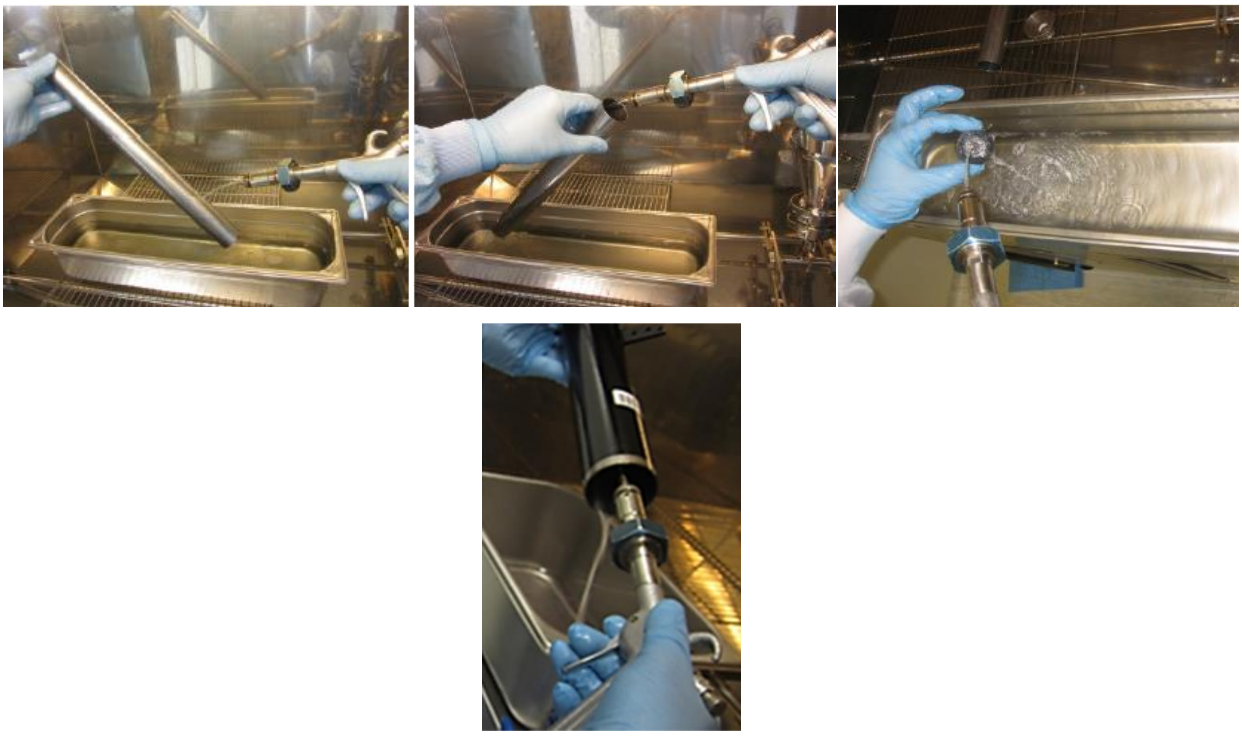

Fig. 7 Extraction of each the testing components

Spraying parameters:
- 1.5 mm nozzle
- 1 l/min flow rate
- 1500 ml medium

The next step is to fill containers with the liquid (cold cleaner) (Fig. 8). Put the stainless-steel containers into the ultrasonic bath and treat with ultrasonic for 6 minutes (Fig.9).

Fig. 8 Liquid addition

Fig. 9 Ultrasonic bath

Parameters for the ultrasonic bath acc. to WN70/13 U:
- Frequency: 40 kHz
- Power: 25 W/l
- Ambient temperature

After the ultrasonic bath, it is necessary to take out of the container the single parts and rinsed to remove particles attached to the part surface. Collect the rinsing medium in the stainless-steel container.

Finally, we provide filtration of the extraction fluids. The filter holder is assembled in a

few steps. Then use a tweezer to insert a filter (41 μm) onto the top of the neck. The position of the filter is fixed when you install the filter funnel on top (Fig.10).

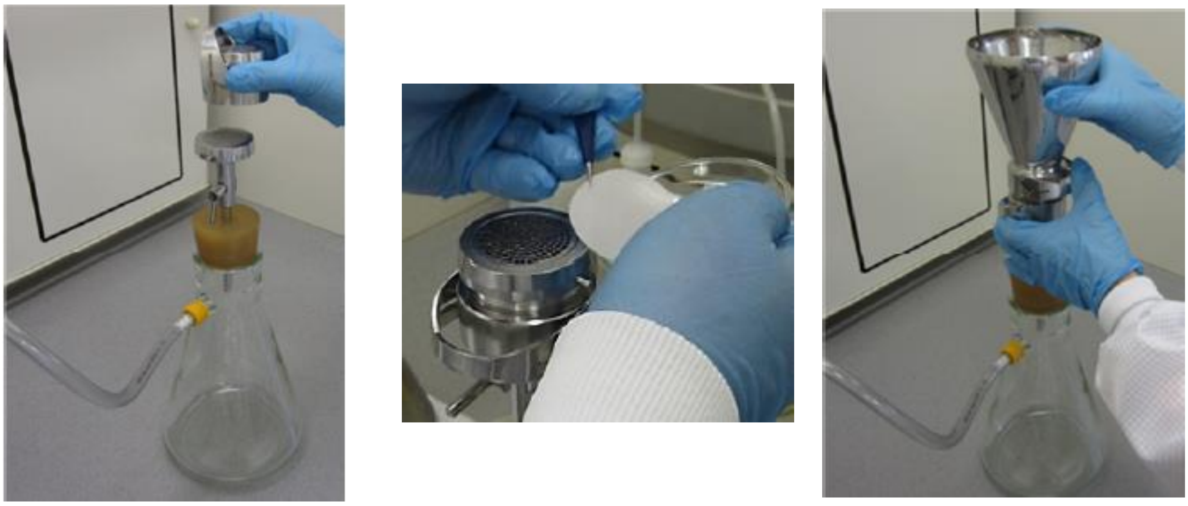

Fig. 10 Construction of filter equipment

Subsequently begins the process of filtering liquids from the containers. Pour the liquid from the reservoir tube over a separate filter. The walls and the bottom of stainless steel container are rinsed several times with spray gun and the fluid is poured over the filter. The funnel is rinsed two times in circulated movements. This time use cold cleaner from the wash bottle.

Fig. 11 Filtration

After that the funnel is removed and the filter even drawn to the watch crystal and cover with the right labeled watch crystal (Fig.12).

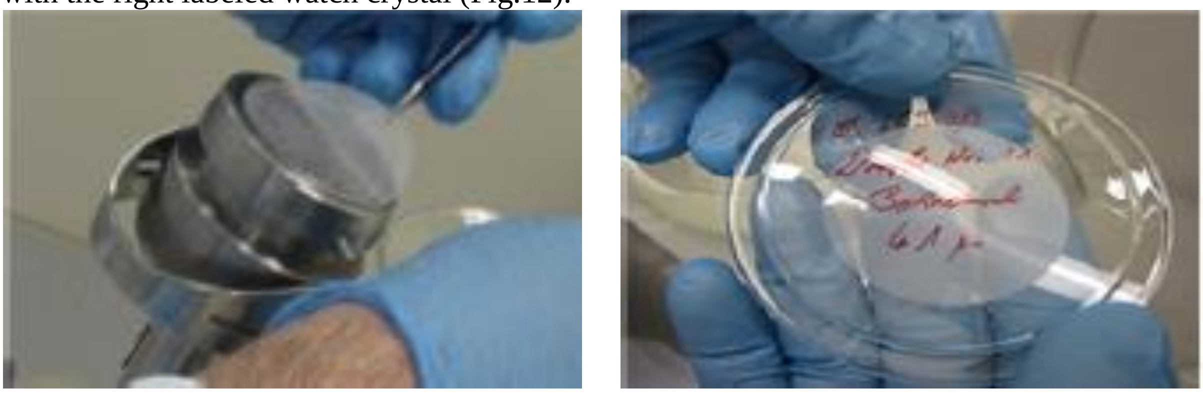

Fig. 12 Filter in the watch crystal

RESULTS

This procedure is repeated with all containers. So we get a four full samples that are inserted into the dryer (Fig.13).

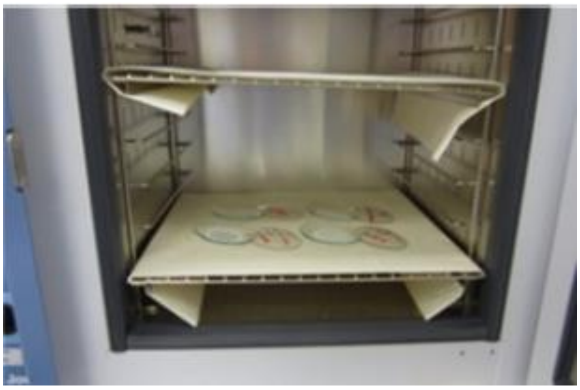

Fig. 13 The dryer

The four filters (blank value, container, valve components, oil) are dried in an oven without recirculating air at 100°C for one hour. After the drying, the filters need to be cooled down in the desiccator for one hour. As long as the filters are warm, the filter weight is incorrect.

CONCLUSION

The filters are analyzed gravimetrically and visually for the largest particles. Determine the weight of the filters (Fig.14) and perform visual inspection using the Jomesa microscope (Fig.15).

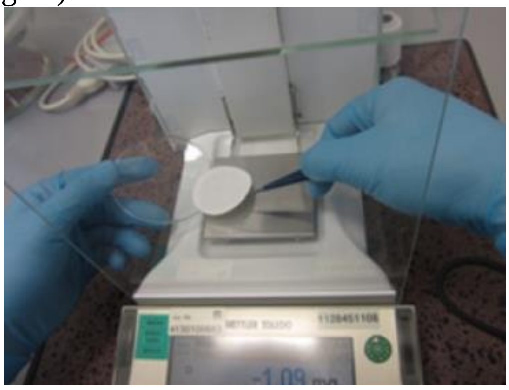

Fig. 14 Filter weighing

Fig. 15 Jomesa microscope

The Jomesa software automatically generates a log of the largest (shiny) metallic and (non-shiny) non-metallic particles as well as fibers [length, width]. A trained person has to verify the results of the Jomesa evaluation as recognition errors occur frequently. Bent particles are separated, for instance, so their measured length is shorter than they actually are. Also, particles may lie so close to or on top of each other that they are recognized as a single particle. In the first case, the parts of the particle need to be joined manually, and in the second case the particles need to be separated manually. Afterwards, the calculation is repeated and it has to be checked whether the corrections have been incorporated.

At the end, the final document shows the results of residual contamination and pictures from the Jomesa microscope. Once the evaluation is completed, the filters are archived in a plastic Petri dish. To do so, label the plastic Petri dish with the required data (inspection order number, part designation and/or part number, filter size).

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CONTACTS

Zuzana Csillagová, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak university of agriculture in Nitra, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia, e-mail: xcsillagova@is.uniag.sk

Gabriel Poló, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak university of agriculture in Nitra, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia, e-mail: xpolo@is.uniag.sk

Plamen Kangalov, Department of Repair and Reliability, Agrarian and Industrial Faculty, University of Ruse, 8, Studentska Str., 7017 Ruse, Bulgaria, e-mail: kangalov@uni-ruse.bg

Ivan Beloev, Department of Transport, Faculty of Transport, University of Ruse, 8, Studentska str., 7017 Ruse, Bulgaria, e-mail: ibeloev@uni-ruse.bg

Ľubomír Beláň, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak university of agriculture in Nitra, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia, e-mail: xbelan@is.uniag.sk

Maroš Korenko, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak university of agriculture in Nitra, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia, e-mail: maros.korenko@uniag.sk

Cooperation of Information Technologies, Software and Quality Tools In Terms of Quality Options and Information Back Up and Documents In the Conditions of Quality Management Systems

Gabriel Polo, Hristo Beloev, Zuzana Csillagova,
Martin Balaz, Lubomir Belan, Maros Korenko

Abstract: *The technical and technological procedures used to monitor the patient's life functions, when reading data from both the recorded data and archiving, use the storage media (SD cards) on which the life functions are recorded. This archiving is carried out at certain time intervals on the main disk in the main folder for storing important information. In further sections of this scientific article we will present the possibilities and intervals of recording individual archives from the instruments at individual emergency medical stations. This is in particular the way of actual archiving, its capabilities and possible improvement through selected quality tools, which can significantly increase the efficiency of archiving the information as well as strengthen the implementation of quality systems in this area.*

Keywords: *monitoring, recording, archiving, SD Cards*

INTRODUCTION

In the presented scientific article, we will deal with the current method of archiving data from medical devices as well as with some suggestions for improvement of the used sequences. An important point is to mention from a technical point of view the security controls of the given devices as well as certain suggestions based on professional literature as well as some used paper forms. These qualitative tools can significantly improve the methods used to verify the reliability and security of the devices in terms of functionality, quality and archiving of important information. An important part of these methods is also the implementation of quality tools and methodologies not only in the work sequences, but generally in the process function sequences. Based on these important features, the so-called process approach as well as complex process management and an effective tool are important in the given conditions of the organization as a whole as well as the procedural parts of the individual focus. The methodology can then be branched out into further process methodologies, whether in the technical, technological or archiving process in terms of all priority issues.

MATERIAL AND METHODS

Methodological solutions to these issues can be made in several ways where it is very important to mention useful and effective quality tools in synergy with information systems in the application of selected methods, tools and techniques of quality management systems. An example is the efficient collection and archiving of data from the ECG monitor and defibrillator where archiving from individual devices is registered into the defibrillator backup table and, if necessary, the records can be viewed using the CorView2 software.

The application of some quality methods is so complex in terms of scope and mathematical apparatus that the usage time may outweigh the effect of the application itself. In such a case, it is appropriate to use a corresponding information system that increases the efficiency of the individual methods. In principle, companies may choose to proceed with the appropriate information system as follows:

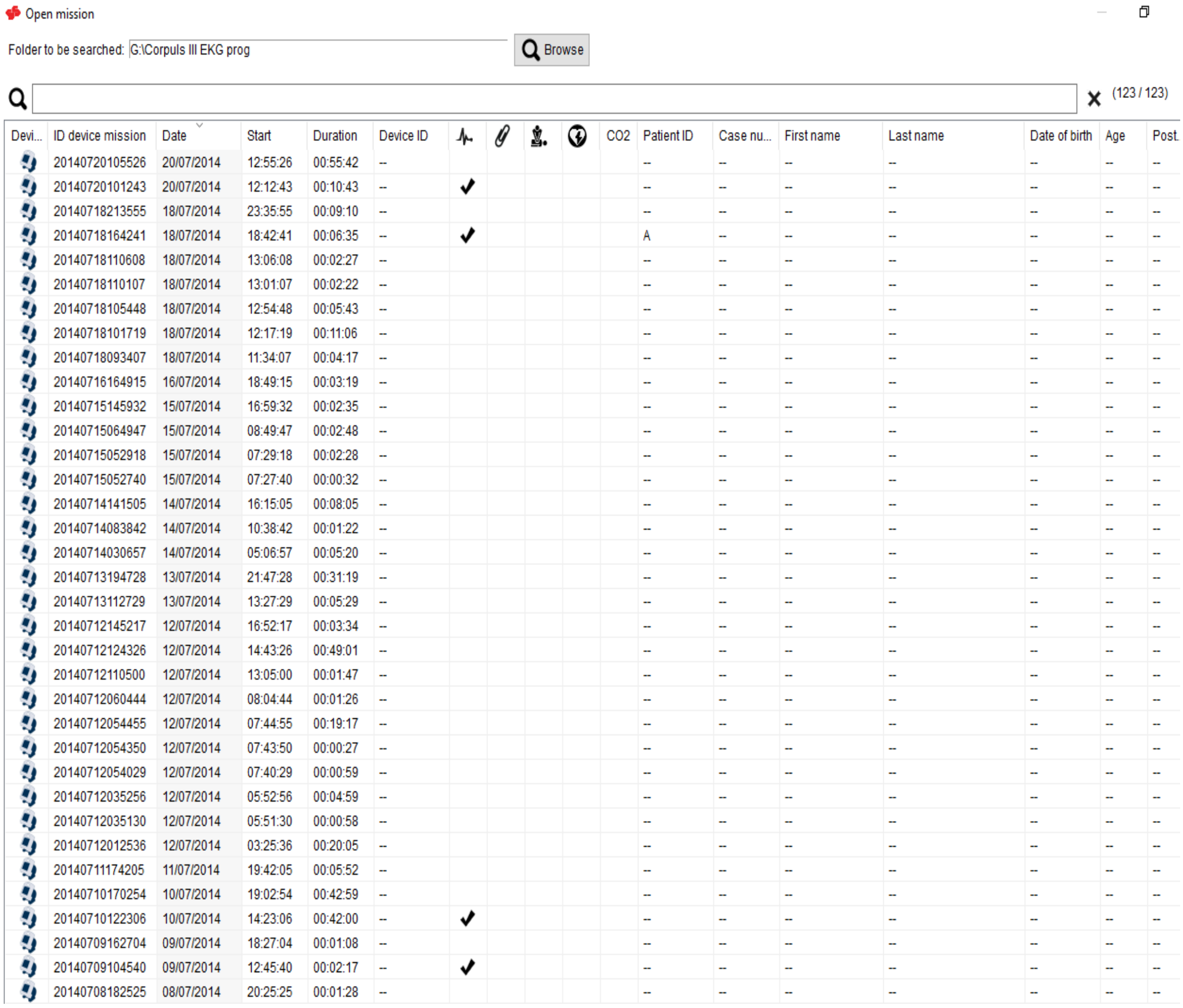
1. choose a **specific software tool** that was created only for the application of a particular method and cannot be used for the application of another method,
2. Use **standard tools** that allow formulation of custom relations and solution processes.

Both options have their advantages and disadvantages. In the case of a specific software

tool, it is not important to concentrate on the algorithm to solve the given method but, above all, to correctly define the input data and parameters. The advantage is in this case:

- simplicity and application speed of the given method,
- managing application results are clear and structured,
- there is no need for a deep understanding of the solution's algorithm.

The greatest disadvantage of using a specific software tool is its limited use in the application of other related methods, and in particular its high price. A clear advantage of using standard software is its low cost. The disadvantage is the need to use more software. It is good if all come from one manufacturer. For example, MS Visio allows creation of IDEF0 process maps with different hierarchies and links to other documents. MS Project is suitable for tracking customized production processes with tracking indicators such as time, cost, human resources.



Devi...	ID device mission	Date	Start	Duration	Device ID					CO2	Patient ID	Case nu...	First name	Last name	Date of birth	Age	Post.
	20140720105526	20/07/2014	12:55:26	00:55:42	--						--	--	--	--	--	--	--
	20140720101243	20/07/2014	12:12:43	00:10:43	--	✓					--	--	--	--	--	--	--
	20140718213555	18/07/2014	23:35:55	00:09:10	--						--	--	--	--	--	--	--
	20140718164241	18/07/2014	18:42:41	00:06:35	--	✓					A	--	--	--	--	--	--
	20140718110608	18/07/2014	13:06:08	00:02:27	--						--	--	--	--	--	--	--
	20140718110107	18/07/2014	13:01:07	00:02:22	--						--	--	--	--	--	--	--
	20140718105448	18/07/2014	12:54:48	00:05:43	--						--	--	--	--	--	--	--
	20140718101719	18/07/2014	12:17:19	00:11:06	--						--	--	--	--	--	--	--
	20140718093407	18/07/2014	11:34:07	00:04:17	--						--	--	--	--	--	--	--
	20140716164915	16/07/2014	18:49:15	00:03:19	--						--	--	--	--	--	--	--
	20140715145932	15/07/2014	16:59:32	00:02:35	--						--	--	--	--	--	--	--
	20140715064947	15/07/2014	08:49:47	00:02:48	--						--	--	--	--	--	--	--
	20140715052918	15/07/2014	07:29:18	00:02:28	--						--	--	--	--	--	--	--
	20140715052740	15/07/2014	07:27:40	00:00:32	--						--	--	--	--	--	--	--
	20140714141505	14/07/2014	16:15:05	00:08:05	--						--	--	--	--	--	--	--
	20140714083842	14/07/2014	10:38:42	00:01:22	--						--	--	--	--	--	--	--
	20140714030657	14/07/2014	05:06:57	00:05:20	--						--	--	--	--	--	--	--
	20140713194728	13/07/2014	21:47:28	00:31:19	--						--	--	--	--	--	--	--
	20140713112729	13/07/2014	13:27:29	00:05:29	--						--	--	--	--	--	--	--
	20140712145217	12/07/2014	16:52:17	00:03:34	--						--	--	--	--	--	--	--
	20140712124326	12/07/2014	14:43:26	00:49:01	--						--	--	--	--	--	--	--
	20140712110500	12/07/2014	13:05:00	00:01:47	--						--	--	--	--	--	--	--
	20140712060444	12/07/2014	08:04:44	00:01:26	--						--	--	--	--	--	--	--
	20140712054455	12/07/2014	07:44:55	00:19:17	--						--	--	--	--	--	--	--
	20140712054350	12/07/2014	07:43:50	00:00:27	--						--	--	--	--	--	--	--
	20140712054029	12/07/2014	07:40:29	00:00:59	--						--	--	--	--	--	--	--
	20140712035256	12/07/2014	05:52:56	00:04:59	--						--	--	--	--	--	--	--
	20140712035130	12/07/2014	05:51:30	00:00:58	--						--	--	--	--	--	--	--
	20140712012536	12/07/2014	03:25:36	00:20:05	--						--	--	--	--	--	--	--
	20140711174205	11/07/2014	19:42:05	00:05:52	--						--	--	--	--	--	--	--
	20140710170254	10/07/2014	19:02:54	00:42:59	--						--	--	--	--	--	--	--
	20140710122306	10/07/2014	14:23:06	00:42:00	--	✓					--	--	--	--	--	--	--
	20140709162704	09/07/2014	18:27:04	00:01:08	--						--	--	--	--	--	--	--
	20140709104540	09/07/2014	12:45:40	00:02:17	--	✓					--	--	--	--	--	--	--
	20140708182525	08/07/2014	20:25:25	00:01:28	--						--	--	--	--	--	--	--

Fig 1 Illustration of archived defibrillator records from the SD cards in corView2 software

MS Excel is able to solve problems of statistical quality management. However, the use of different programs requires a lot of work and concentration on the connections between them, which is their major disadvantage. However, the deployment of a relevant software also depends on other criteria that are rather organizational and economic. These include, for example, business size, process complexity, software cost, and additional costs for updating, software support options of the provider, additional training, and other business references,

and more. Based on these important information, it is possible to compile several effective tools for collecting information e.g.: for archiving documents from ECG devices as well as universal pulmonary ventilators.

RESULTS AND DISCUSSION

The MS Excel spreadsheet is an excellent tool for defining various mathematical functions and using them for applying different quality methods. It contains a number of predefined functions. The greatest possibilities of its use are mainly in statistical quality management. An important feature of the MS Excel spreadsheet is collecting information about data collection from the devices.

Table 1 Creating arch. rec. to perform the main archiving of ECG and UPV according to the prescribed schedule

Checking and registering records from defibrillators and UPVs (checking SD cards and uploading data to an external disk)					
Station	***Date***	***Equipment***	***Serial / inventory number***	***Filename or remark***	***Responsible tech.***
MES Komárno 1	03.08.2016	Corpuls3	100138	MES Komárno 1. 03.08. 2016	-
MES Komárno 2	03.08.2016	Corpuls3	100170	MES Komárno 2. 03.08. 2016	-
MES Zemian. Olča	03.08.2016	Corpuls3	100178	MES Zemianska Olča 03.08. 2016	-
MES Veľký Med.	03.08.2016	Corpuls3	100173	MES Veľký Meder 03.08. 2016	-
MES Nesvady	04.08.2016	Corpuls3	100181	MES Nesvady 04.08. 2016	-
MES Trstice	03.08.2016	Corpuls3	100177	MES Trstice 03.08. 2016	-
MES Kolárovo	04.08.2016	Corpuls3	100169	MES Kolárovo 04.08. 2016	-
MES Komjatice	04.08.2016	Corpuls3	100176	MES Komjatice 04.08. 2016	-
MES Marcelová	05.08.2016	Corpuls3	100175	MES Marcelová 05.08. 2016	-
MES Pribeta	04.08.2016	Corpuls3	100174	MES Pribeta 04.08. 2016	-
MES Štúrovo	04.08.2016	Corpuls3	100172	MES Štúrovo 04.08. 2016	-
MES Gbelce	04.08.2016	Corpuls3	100179	MES Gbelce 04.08. 2016	-
MES Želiezovce	04.08.2016	Corpuls3	100171	MES Želiezovce 04.08. 2016	-
MES Podhájska	04.08.2016	Corpuls3	100180	MES Podhájska 04.08. 2016	-

Presented records are carefully preserved according to the prescribed time intervals and the prescribed method so that all required matters and information are effectively captured. For possible additional security and quality information procedures within quality management systems, it is possible to focus on the synergy of these tools together with effective quality tools that can be used primarily to enhance security and retention of information. These quality tools can be presented not only by a flowchart or the Ishikawa diagram but as well as by a checklist which can be a significant strengthening of these important tools. Based on this information, we can list at least two examples of document archiving where these quality tools prove to be of great importance.

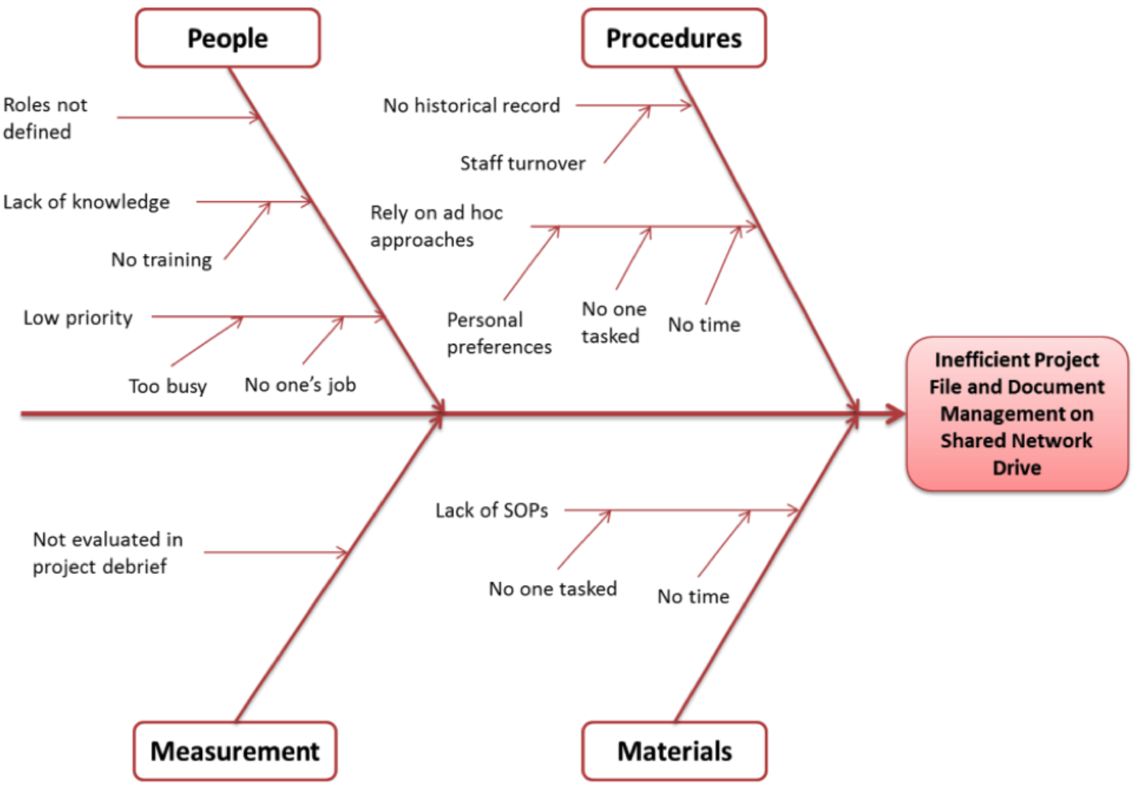


Fig 2 Diagram of causes and effects in improving electronic document archiving

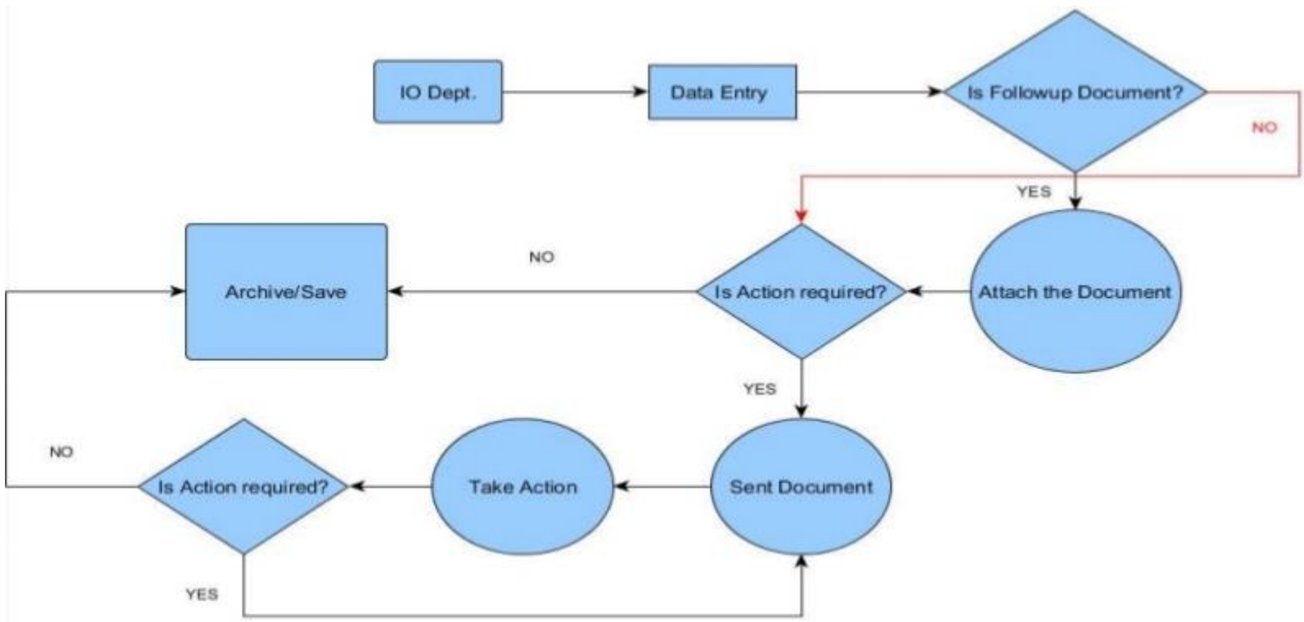


Fig 3 An example of using a flowchart for document archiving

Graphically, we can see the correlation of the important information and process steps of archiving such as the effective use of quality tools, and, in the case of other options, it might be possible to attach, for example, also the mentioned check sheet as a certain type of process control of adherence to each sequence during the archiving of individual document types as important part of the quality management systems.

CONCLUSION

The operational processes and procedures have to be defined, documented and updated as necessary. The structuring of the different levels of documentation, records and data has to be defined, efficiently and operationally managed. Records are documents that show achieved results or provide evidence of proven work. Records are evidence of the activity being performed and are generated during the implementation of activities in the organization.

The purpose of records management:

- keep data on suitable medium for a certain period of time at an appropriate location,
- make the data available to all defined functions in the organisation.

Based on the above information, it is of utmost importance in each organization to determine an efficient and very secure way of archiving information and records that show the very important internal information of the selected organization. Therefore, it is very important to have an efficient functional interplay between archiving records, information technologies and effective tools of quality management systems.

ACKNOWLEDGEMENT

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CONTACTS

Gabriel Poló, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak university of agriculture in Nitra, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia, e-mail: xpolo@is.uniag.sk

Hristo Beloev, Department of Agriqulture machinary, University of Ruse, Studentska str. 8, Ruse, Bulgaria, e-mail: hbeloev@uni-ruse.bg

Zuzana Csillagová, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak university of agriculture in Nitra, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia, e-mail: xcsillagova@is.uniag.sk

Martin Baláž, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak university of agriculture in Nitra, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia, e-mail: xbalazm4@is.uniag.sk

Ľubomír Beláň, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak university of agriculture in Nitra, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia, e-mail: xbelan@is.uniag.sk

Maroš Korenko, Department of Quality and Engineering Technologies, Faculty of Engineering, Slovak university of agriculture in Nitra, Trieda Andreja Hlinku 2, 949 76 Nitra, Slovakia, e-mail: maros.korenko@uniag.sk

Gender Sensitivity as One of the Factors in the Management of Technical Projects

Helena Kolibova, Pavel Machal, Ivan Beloev, Lubica Libova

Abstract: *The labour market area is characterized by a vast variety of approaches to human diversity in terms of gender, ethnicity, age, sexual orientation, etc. The strategy of the European Union and national economies emphasizes creation of such policies which try to compensate for consequences on a decrease in the number of active population by strengthening the labour market particularly in favour of gender-profiling groups such as the elderly, women and parents returning to the labour market after parental leave, etc. Based on their experience, male/female employees and employers are forced to rethink their ideas, future strategies and practices flexibly. However, there is a plurality of paradigms. The issues of project management and human resources can be seen in a broader perspective. The ambition of this paper is to highlight the implementation of gender sensitivity in managing technical projects. The current emphasis is not only placed on project managers´ knowledge and experience in the field of behavioural competencies, but it is also placed on their knowledge how to apply the competencies in the management of technical projects such as gender sensitive political strategy. The study of gender inequality is based on horizontal and vertical segregation levels.*

Keywords: *Project Management, Labor Market, Human Resources, Technical Projects*

INTRODUCTION

Management can be simply understood as the science and art of managing business activities (e.g. according to Drucker´s opinions). Critical processes that are considered to set business objectives are planning, organizing, operational controling, leading, or coordinating and decision-making. The concept of professional management is given a modern interpretation based on proper functioning of its three components – organization, communication and information. It is usual to label initial conceptions of management simply as management. The most important of these are Process management, Scientific management, Modern theory of operations management, Behaviorism, Systems theory, Modern concepts of management, and also Project management.

Project management is a special discipline also called ‘philosophy of management’, modern management concepts of complex, discrete planning tasks with a high degree of indefiniteness and complexity. In other words, a special approach to the processes of planning, organizing, coordinating, controlling and decision-making in all aspects of processes called the project. It includes motivating all involved staff in order to achieve the project objectives. It means to achieve a required product category and quality at the output in compliance with meeting deadlines, costs and risks (Doležal, J., Máchal,P., Lacko, B., a kol.) Process management is a term that may represent a synonym for ‘project management’. Howevere, in the Czech Republic this term is used to describe a more specified process related primarily to issues of operations management for specific projects.

The paper aims to discuss the gender sensitivity in the management of technical projects. It is generally accepted that especially some ‘soft’ projects are managed by female project managers. Nonetheless, this practice is not so common in the field of the management of technical projects.

Political and organizational negotiations and activities on the labour market are never gender-neutral. Various life situations may be reflected in differentiated labour market status of an individual and cause unfavourable impacts according to various aspects such as gender, age, ethnicity, etc. Therefore, the society requires companies to obey a number of rules which are becoming, more or less, a part of corporate strategies. They are implemented in activities of multinational and local businesses.

Introducing a gender issue into society and companies is exposed to the contrast of formal declaration of equality and maintain the current image of a divided world

(KOCMANOVÁ, A., HŘEBÍČEK, J., a kol.). Researches show the validity of value and cultural transmissions which are influenced by a 'toxic cultural environment' (Killbourne, J. Levin, D.). Certain domains are being commonly attributed to gender-profiling groups, i.e. women and men have predetermined completely different talents, qualities, or ambitions. Processes have been developed since the 1980s. They emphasize the fact that genderism is occurring in organizations at least in four interrelated processes (Křížková, A., Pavlica, K..):

a) **Division within gender lines –** represents a work division, acceptable behaviour, space and power controlling. Women in companies are mostly employed in personnel departments and men are more frequently working in technical and operational departments. Women express their emotions in a different way than men.They are allowed to cry but swearing or profanity is not tolerated.

b) **Design of symbols and images** – represents the creation and maintenance of symbols and images that explain gender division. For example, a dresscode (the dresscode both for men and women without ornamentation), design of corporate printed materials, pictures of men and women depicting the superior position of men, e.g. a man standing and dictating something, a woman watching and writing; a young person is considered to be more efficient, an aged employee do not possess ICT skills, etc.

c) **Interaction among participants** – helps maintain established inferior/superior workplace relationships. Men usually behave like mentors, instructors, while women provide them with emotional support and are willing to lend an ear. Young people are more vigorous and energetic; the Caucasian race is more valuable; elderly people are unpromising. If a man raises his voice during a group discussion, it is widely considered to be the element of emphasis. In case of similar female behaviour, raising voice is identified as a note of hysteria.

d) **Production of identities –** represents an internal and external policy of compliance with official gender culture in an organization. Employees adopt their roles in the company as a natural part of their own identity.

MATERIALS AND METHODS

In order to determine working methods, authors worked on both basic characteristics of the management of technical projects and the analysis of female participation on the labour market in the Czech Republic. The competency standard of project management IPMA was used as a starting basis. Different types of organizations were distinguished in the context of gender equality:

− **Gendered organization** – corporate culture is still influenced by a stereotyped image in companies and solves the dilemma of relevant feedback on making a profit. A limited range of roles is adopted where women are considered to be mothers or caregivers with a narrow focus on career advancement, while men are perceived as dominant authoritative people with technical specialization and skills. Such organization is little interested in maintaining work-life balance showing a lack of respect for current hedonistic tendencies of individuals to enjoy all the roles including an opinion that childcare is a matter of women. It shows one-sided favouritism towards one gender in organizational processes. For example, a possibility of a flexible return after parental leave is not guaranteed as well as conditions for providing a care for ill family members or aging parents, or a lack of working conditions for older male/female workers, etc.

− **Gender-integrated organization** – it operates in cultural dimensions based on norms, values, and practices of gender equality and its principles. Corporate culture is becoming stronger. In fact, it means that companies monitor gender issues in practice. They are, more or less, mindful of proportional representation of women and men in managerial positions, promote career development of their male/female employees, and guarantee for their equal pay.

RESULTS AND DISCUSSION

The analysis of female participation on the labour market in the Czech Republic shows that there is a variety of factors which often have an impact on the path and progression of women's career (KOLIBOVÁ, H.).

They are:

– *Dominating gender norm* which is mostly associated with the fulfilment of gender roles and career choice. It is made in accordance with gender stereotypes about suitability of certain jobs for men and women. Workers in stereotypically 'male' professions are better employed on the gender-segregated labour market with a guarantee of higher salaries, steady jobs with better working conditions and more favourable opportunities for career advancement. Such professions are associated with higher social status. In contrast, the secondary labour market with typically 'female' professions offers low salaries, poor working conditions with limited options of career advancement, limited autonomy and no authority for making decisions, limited training opportunities and low-prestige jobs. (KŘÍŽKOVÁ)

– *Changing social and institutional conditions, family background charakteristics* – disproportionate representation of women and men in certain types of jobs is largely related to their different levels and branches of study and different preferences for their chosen career. The difference in preferences can be either innate or caused by gender stereotypes. The stereotypes may either facilitate or complicate access to jobs, organizations, and groups of respective companies.

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– *Factors affecting participants in their career choice* – benefits, financial incentives, career opportunities. In order to distinguish gender norms we differentiate between a horizontal segregation which refers to the amount of people of each gender across occupations, sectors and disciplines, and a vertical segregation which describes men's or women's domination at various levels of organizational hierarchy. Feminization of some professions and posts seems to be an important manifestation of labour market segregation from the perspective of gender. Jobs and professions where women make up more than 70% of all workers are marked as feminized. These jobs are gradually credited all the stereotypical feminine characteristics such as sensitivity, ability to care for others, devotion, empathy, patience, etc.

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– *The role of individual factors in career choice* – ambition, expectation. There is already some discrimination before entering the labour market which is evident from actual job offers. Employers attribute some job positions only to men and some only to women. The wording of adverts sometimes discriminate covertly against young or older women, women with children or women who are seeking rewarding and highly paid jobs. Companies as well as male/female candidates make decisions based on what they are possibly expected to do (set patterns for rights, responsibilities, procedures, methods, and techniques of presentation). Certain restrictions, which are related to career stages or age that is advancing, are applied. However, they are replaced by other modes, e.g. detachment, or social relationships in the workplace.

Stimulation tools to involve gender-defined workers can be divided into three basic groups:

– *legislative tools,* which consist mainly of laws that uphold the equal status of gender-profiling groups on the labour market, prevent male/female aged workers and disabled workers from discrimination, etc.,

– *benefits and other tools,* which are mainly based on providing a sufficient number of various courses and training for gender-profiling groups,

– *motivation tools,* which inspire an interest in lifelong learning in gender-profiling

groups.

An example shows the connection between different levels of society and the dynamics of social changes.

Table 1 Types of social changes in the implementation of strategies for equal opportunities

	Micro-level	**Meso-level (group)**	**Macro-level (society)**
Short-term changes Example:	**Behaviour change** Acceptance of information on gender balance Growing awareness of the forms of gender balance	**Change of norms, administrative change** Impact restrictions of the assessment by stereotypes, sexist forms of communication – double entendre, seemingly neutral slogans, offensive means of communication.	**Policy change** Elimination of all forms of discrimination based on gender, age, ethnicity, sexuality, or gender identity.
Long-term changes Example:	**Lifestyle changes** Intolerance to features of sexistic and gender stereotyped behaviour – stereotyping, objectification, sexualization, fragmentation, violence against women, elderly people, etc.	**Change in corporate behaviour** Respecting the gender dimension of personnel agenda in companies, improving reputation and enhancing the company's credibility. *Systematic promotion of equality in remuneration, career progression*.	**Socio-cultural development** Open society respecting dignity, without discrimination on any ground such as race, nationality, gender, age, physical disability, or sexual orientation. *The shift from verbal manifestation to the use of specific aid instruments.*

Source: Author

Gender competence is accepted by theoretical and practical spheres as a new key competence, which is profiled as a natural part of both individual and company's professionality (SOKAČOVÁ L.). It includes elementary awareness of gender politics in society, gender-sensitive political strategies adopted by potentially applicable instruments in meeting requirements for gender equality in society (gender mainstreaming), and general perception of gender as a social category.

Segments of gender competence:

– *Social competence* – ability to work with gender-profiling groups (not only with men, women, transgender, intersexuals, or people with disabilities or somehow limited by their race or ethnicity).

– *Individual competence* – gender is the issue of individuals who regularly perform their various activities within their interactions so as to reflect male/female gender and normative social expectations related to people of their gender. They constantly depict men and women and their 'natural' difference although many of the situations, in which they do so, may not seem relevant at first glance from gender perspective.

– *Professional competence* –knowledge of processes, skills in making new connections

relating to equal opportunities, gender structures, gender-diferentiated solutions, respect for the model of working life from the beginning to the end of employment, meaningful ways of employing diverse teams in terms of age and experience, which are able to transfer their knowledge, experiences, and contacts.

− *Methodical competence* – conditions for perception of complex structures of gender relations in society, politics, administration, and organization.

Gender sensitivity and its effects:

− to mobilize the interest of skilled employees in terms of interest and options, e.g. workers' inspiration and creating a culture of commitment, improvement, and accountability.

− to enhance the motivation for productivity, affect promoting values for customers (a company may utilize competencies, information, and authorization of male/female employees; a manager is able to communicate, coach, and lead), inspire creative and innovative environment and a low turnover of staff.

CONCLUSIONS

Studies and social theories have not interpreted the progress and impact of analyses concerning gender relations on the labour market adequately so far. The authors' objective was to convey a gender context and its influence on the acceleration of new social risks. Specifically, the prevention and responses of companies and businesses represent key points that are able to point out the negative aspects of general identifying characteristics of gender-profiling individuals.

Gender sensitivity of individuals (managers at all levels of organizations) and its qualitative diversity is based on three sources.

− It is about *understanding of one's own experience* within the scope of stereotypical characteristics and behaviour towards gender-profiling groups such as elderly people, women, men, parents returning to the labour market after parental leave, people from ethnic minorities, etc.

− It is about *understanding the corporate culture of a particular company*. The company strategy is obviously aiming at making a profit in business. However, in order to remain competitive, companies must have some capability of their human resources development (i.e. including gender approach to their employees) as well as the exploitation of necessary technologies, etc. This raises the problem of a limited range of roles where gender-profiling groups are accepted whether it is the hierarchy of roles in a company or the focus on performance, the cult of youth, or belonging to the majority population, etc.

Understanding the corporate culture with its perspective on the content and technical aspects of gender issues consists both in the legislative base and apparently in specific examples of good practice in the transfer of experience.

Data analysis of the enterprise must respect the quality diversity of lived experiences and their significance. In this perspective, it is recommended to put social pressure on:

− respecting equal opportunities in employment on the regional labour markets,

− policy support of corporate social responsibility, i.e. ecology and sustainable development,

− company management based on the vision and integrity, which is able to optimize the policy of strengthening the corporate culture, that is:

- regular monitoring of gender issues in established practice, innovation of human resources processes with a special emphasis on the education of employees in the field of gender stereotypes, and overcoming other prejudices, e.g. race prejudices, etc.
- training for the purpose of strengthening professional competencies may have many forms in a corporate environment, e.g. initial trainings for recruits, further

education in the form of workshops, seminars, study materials, language learning, vocational training, soft skills training, etc.

- learning by good examples; mentoring and coaching with manuals for practical use with interactive elements led by experienced professionals and managers, who have an exclusive position in lifelong learning. They guarantee the transfer and applicability of theoretical knowledge into practical needs where specific social and managerial skills are practised.

The purpose of these social activities is to promote a rich and differentiated gender-sensitive environment which is reflected in a functioning management. According to modern interepretations, this depends on the balanced configuration of three components – organization, communication and information.

SUMMARY

The aim of the paper was to uncover and identify gender issues concerning gender-profiling groups such as the elderly, women and parents returning to the labour market after parental leave, people from ethnic minorities, who are an integral part of the labour market. The awareness of these facts may affect employment policie both in a positive and negative way. The stated issues are complex in nature. They are interrelated and can not be addressed only from one perspective.

The data analysis dealt with defining the qualitative diversity of gender structures. The research has shown that there are broad differences in a corporate practice both in terms of implementation strategies and the atmosphere in the organization. The analysis has focused on indicating and identifying the resources which determine the degree of gender sensitivity of individuals. Eventually, the profile and level of its structure shapes the corporate culture of human resources. In the opposite direction, it affects communication in companies both at vertical and horizontal levels. The proposed measures allow greater flexibility within the professional framework. Maximum productivity can be only ensured if employees are able to gain control over their working patterns of behaviour in professional communication.

The paper aims to make a contribution to further discussion on the culture of gender sensitivity on the labour market, orientation and specificity of the topic in the business sphere. It turns out that human resources management can not ignore the influence of social changes and development that we are currently witnessing.

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CONTACTS

Helena Kolibová, The Institute of Public Administration and Regional Policy, Faculty of Public Policies in Opava, Silesian University in Opava, Hradecká 17, 746 01 Opava, Czech Republic, e-mail: helena.kolibova@fvp.slu.cz

Pavel Máchal, Department of Project Management, The Faculty of Regional Development and International Studies, Mendel Univerzity in Brno, 613 00 Brno, Czech republic, e-mail: pmachal@mendelu.cz

Ivan Beloev, Department of Transport, Faculty of Transport, University of Ruse, 8, Studentska str., 7017 Ruse, Bulgaria, e-mail: ibeloev@uni-ruse.bg

Lubica Libova, Vysoká škola zdravotníctva a sociálnej práce sv. Alžbety, Palackého č. 1, P.O. Box 104, 810 00 Bratislava, Slovakia